Bellefonte Nuclear Plant
Preoperational Monitoring Report
1974-1979
Volume I

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1.0 INTRODUCTION

TVA filed with the Atomic Energy Commission (AEC) now the Nuclear Regulatory Commission (NRC) in May 1973 an application to construct the Bellefonte Nuclear Plant (BNP) in Jackson County, Alabama.

In accordance with the National Environmental Policy Act of 1969 (NEPA)(42 U.S.C. Sections 4331 et seq), TVA prepared a Draft Environmental Impact Statement (DEIS) which was sent to the Council on Environmental Quality (CEQ), State of Alabama and Federal agencies, and made available to the public in March 1973.

TVA's Final EIS was sent to the CEQ and made available to the public May 24, 1974. The Final EIS for the BNP, Units 1 and 2, issued May 24, 1974, served as a licensing document. Construction permits for the facility were issued by the AEC and received by TVA on December 24, 1974.

The preoperational water quality and aquatic flora-invertebrate fauna monitoring programs were implemented in the vicinity of the plant in February 1974 and terminated in October 1979. Proposed plans for these monitoring programs were described in the TVA Final EIS. The Environmental Report Operating License Stage (OLER) contains the monitoring program as implemented and modified during the sampling period. The monitoring program was conducted in accordance with the requirements of NPDES permit No. AL0024635.

This report compiles and analyzes data collected offsite during the period of record and provides a summary description of the aquatic environment in Guntersville Reservoir in the vicinity of the BNP. Much of these data from 1974 through 1976 have been previously included in appendix F1 and appendix F2 of the OLER Report. More recent data evaluations have been made in the BNP Construction Effects Monitoring Report (April 1980). This report constitutes TVA's description of pre-operational baseline aquatic ecological conditions in Guntersville Reservoir in the vicinity of the BNP and is submitted in accordance with NPDES permit conditions and the NRC's Construction Permit.

2.0 SITE CHARACTERISTICS

Introduction

The BNP is located in Jackson County, Alabama, approximately 6 miles northeast of Scottsboro and 38 miles east of Huntsville. The plant site, located at Tennessee River Mile (TRM) 391.5, is on a peninsula bounded on two sides by the Town Creek embayment and on the third side by the Tennessee River. The plant intake is located at TRM 392.1 and the discharge channel at TRM 390.4. The floodplain between the Bellefonte site and the old river channel was flooded by the impoundment of Guntersville Reservoir in 1939. This area now exists as backwater sloughs and embayments (overbanks) which are protected from wave and current action of the main river by strip islands and bars formed by the higher portions of the old river bank. These backwater areas adjacent to the Bellefonte site as well as the river channel support a variety of aquatic flora and fauna.

River Flow and Morphology

The construction site is 42.5 river miles upstream from Guntersville Dam and 33.2 river miles downstream from Nickajack Dam. Flows and water levels are regulated by the operation of these dams.

Normal minimum pool level of Guntersville Reservoir is 593 feet above sea level. Normal full pool is 595 feet above sea level, and the top of the Guntersville Dam gates is 595.44 feet above sea level. The reservoir may be drawn down to elevation 591 during flood control operations. The lowest headwater elevation after initial filling was 590.65 feet on November 12, 1968. The highest headwater elevation since closure of Guntersville Dam was 596.29 feet on March 2, 1944.

The stream gage nearest the site is a U.S. Geological Survey gage located at TRM 418.1 near South Pittsburg, Tennessee. This gage was moved to its present site in August 1965 from a point 11.7 miles upstream, where it was originally established in 1930. Data for minimum, maximum, and daily discharges at the gage were examined for the period 1931 through 1979. The minimum daily average flow during the period was 2900 cubic feet per second (cfs) on November 1 and 15, 1953, and was the result of regulation by Chickamauga and Hales Bar Dams (replaced by Nickajack Dam in 1967). The 7-day, 10-year minimum flow is estimated to be 11,300 cfs; and the 3-day, 20-year minimum flow is estimated to be 8400 cfs.

Average flows past the Bellefonte plant site are approximately 3 percent greater than flows at the South Pittsburg gage. The average streamflow past the site is estimated to be 38,400 cfs based upon 36 years of record at the gage.

Flows past the site are unsteady because releases from Guntersville and Nickajack Dams are usually regulated by electrical power demands. Periods of zero and reverse river flow at the site occur frequently, but rarely last more than half a day.

3.0 OVERVIEW OF WATER QUALITY AND AQUATIC FLORA-INVERTEBRATE FAUNA PREOPERATIONAL MONITORING PROGRAM (NONRADIOLOGICAL)

The nonradiological water quality and aquatic biology (nonfish) monitoring programs described in OLER Section 6.1 and appendices F1 and F2 were implemented in the vicinity of the BNP in February 1974 and were continued through October 1979. During these years, samples were collected at quarterly (water quality) and monthly (biological) intervals from February through October. The monitoring programs are summarized in tables 3.1 and 3.2 and the locations of sampling sites are shown in figure 3.1. Aerial overflights were initiated in May 1975 and continued on an annual basis through the preoperational monitoring period to determine the extent of aquatic macrophyte communities (table 10.1). Stations selected for monitoring the aquatic macrophyte communities are listed in table 3.3 and map locations are presented in figure 10.1.

No major revisions were made in the monitoring program until March 1978 when the nonradiological biological monitoring program was amended to conform with revisions in plant design (e.g., deflection of the thermal plume to the left or opposite side of the river). These changes prompted the addition of four sampling stations on the left overbank and are summarized in table 3.4. In February 1979, further revisions were made in the original sampling plan, discontinuing the evaluation of several parameters at stations where sufficient preoperational data existed. Those revisions are presented in table 3.5.

Table 3.1

SUMMARY OF QUARTERLY PREOPERATIONAL WATER QUALITY MONITORING PROGRAM (NONRADIOLOGICAL) - BELLEFONTE NUCLEAR PLANT

Location	Horizontal location (%)[a]	Depth(s) (meters)	Physical-chemical measurements	Frequency (Feb to Oct)	Period of record	List of analyses (refer to tables)
TRM 386.4	1	Middepth	Hydrolab,[b] nutrients[c]	Monthly	Mar 78 to Oct 79	4.6
TRM 388.0	30	0.3,5.0	Hydrolab,[d] complete[e]	Quarterly[f,g]	Feb 74 to Oct 78	4.4
	80	0.3	Partial[h]	Quarterly[f,g]	Feb 74 to Oct 78	-
TRM 388.4	1	Middepth	Hydrolab,[b] nutrients[c]	Monthly	Mar 78 to Oct 79	4.6
TRM 389.8	5	-	Hydrolab,[b] only	Monthly	Mar 78 to Oct 79	4.2,4.3
TRM 391.2	60	0.3,5.0	Hydrolab,[d] complete[e]	Quarterly[f,g]	Feb 74 to Oct 78	4.4
	1	Middepth	Hydrolab,[b] nutrients[c]	Monthly	Mar 78 to Oct 79	-
TRM 391.6	95	0.3	Partial[h]	Quarterly[f]	Feb 74 to Oct 78	4.6
TRM 396.8	50	0.3,5.0	Hydrolab,[d] complete[e]	Quarterly[f,g]	Feb 74 to Oct 78	4.5
	50	0.3,1.0,3.0,5.0	Hydrolab,[d] nutrients[c]	Monthly	Mar 78 to Oct 79	-
TCM 0.2	50	0.3	Hydrolab,[d] complete[e]	Quarterly[f,g]	Feb 74 to Oct 78	4.5

a. Percent distance from left bank looking downstream.
b. In situ measurements of temperature, dissolved oxygen, pH, and conductivity made at 1-foot intervals.
c. Organic nitrogen, NO_2+NO_3-N, NH_3+NH_4-N, total phosphorus, dissolved phorphorus, total organic carbon, and alkalinity samples collected.
d. In situ measurements of temperature, dissolved oxygen, pH, and conductivity made at 1.5 meters (5 feet) and at interval depths from surface to bottom to describe a vertical profile of station.
e. Samples collected and analyzed for a comprehensive suite of parameters (refer to tables 4.4 and 4.5 for a list of these analyses).
f. February, May, August, and October.
g. In addition to the regular quarterly sampling, monthly in situ measurements were made for temperature, dissolved oxygen, pH, and conductivity, and samples were collected for alkalinity.
h. Samples collected at 0.3 meters for BOD_5, suspended solids, dissolved solids, turbidity, color, organic nitrogen, NH_3+NH_4-N, NO_2+NO_3-N, total phorphorus, and alkalinity in addition to in situ measurements of temperature, dissolved oxygen, pH, and conductivity.

Table 3.2

SAMPLE LOCATIONS IN GUNTERSVILLE RESERVOIR FOR PREOPERATIONAL BIOLOGICAL MONITORING, BELLEFONTE NUCLEAR PLANT

Station location	Depths sampled (meters): Zooplankton	Depths sampled (meters): Productivity, chlorophyll, and phytoplankton cell counts	Number of samples collected: Periphyton	Number of samples collected: Benthos Dredge	Number of samples collected: Benthos Substrate[a]	Number of samples collected: Sediment
Midchannel (1974-1978)						
Tennessee River Mile 388.0	VT[b]	0, 1, 3, 5	10	10	3	1
Tennessee River Mile 391.2	VT	0, 1, 3, 5	10	10	3	1
Tennessee River Mile 396.8[c]	VT	0, 1, 3, 5	10	10	3	1
Town Creek Mile 0.2		0, 1	10	10		1
Left Overbank (1978-1979)		Phytoplankton Samples Only				
Tennessee River Mile 386.4	VT	0, 1		10		
Tennessee River Mile 388.4	VT	0, 1		10		
Tennessee River Mile 389.9				10		
Tennessee River Mile 391.1	VT	0, 1		10		

a. Rockfilled barbeque baskets.
b. Vertical tow; includes all possible depths.
c. Station was sampled through 1979.

Table 3.3

SAMPLE LOCATIONS FOR AQUATIC MACROPHYTES IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT, GUNTERSVILLE RESERVOIR

Location	Habitat description
TRM 396.8 (Raccoon Creek)	Main stream
TRM 396.0 (Raccoon Creek Mile 0.1)	Shallow overbank
TRM 393.0 (Town Creek Mile 0.2)	Shallow overbank
TRM 391.2 (below discharge)	Shallow overbank
TRM 389.4 (Sublett Ferry)	Main stream
TRM 389.4 (Sublett Ferry)	Shallow overbank

Table 3.4

ADDITIONAL MONITORING STATIONS, BELLEFONTE NUCLEAR PLANT, 1978-1979

Station location	Parameter	Total number of samples	Comments
TRM 386.4, left overbank	Zooplankton	2	Bottom-surf, tow 1/2 m net
	Phytoplankton	4	Replicates-0, 1 m
	Macrobenthos	10	Soft silt substrate
	Sediment	2	In March only
	Temperature profile		1 ft intervals
	DO profile		1 ft intervals
	TOC		Middepth
	Nitrogens (organic, nitrite, nitrate)		Middepth
	Phosphate (filterable + total)		Middepth
	Alkalinity		Middepth
TRM 388.4, left overbank	Zooplankton	2	Bottom-surf, tow 1/2 m net
	Phytoplankton	2	Replicates-0, 1 m
	Macrobenthos	10	Soft silt substrate
	Sediment	2	In March only
	Temperature profile		1 ft intervals
	DO profile		1 ft intervals
	TOC		Middepth
	Nitrogen (organic, nitrite, nitrate)		Middepth
	Phosphate (filterable, total)		
	Alkalinity		Middepth

Table 3.4 (continued)

Station location	Parameter	Total number of samples	Comments
TRM 389.9, left overbank-mainstream side of island	Macrobenthos	10	Clay/sand/silt substrate
	Sediment	2	In March only
	Temperature profile		1 ft intervals
	DO profile		1 ft intervals
TRM 391.1, left overbank	Zooplankton	2	Bottom-surf, tow, 1/2 m net
	Phytoplankton	4	Replicates-0, 1 m
	Macrobenthos	10	Soft silt substrate
	Sediment (texture)	2	In March only
	Temperature profile		1 ft intervals
	DO profile		1 ft intervals
	TOC		Middepth
	Nitrogen (organic, nitrite, nitrate)		Middepth
	Phosphate (filterable, total)		Middepth

Table 3.5

AMENDMENTS TO BELLEFONTE NUCLEAR PLANT NONRADIOLOGICAL ENVIRONMENTAL MONITORING PROCEDURES, EFFECTIVE FEBRUARY 1979

1. Stop collection of all water quality samples at TRM 391.2, 388.0, and Town Creek mile 0.2.

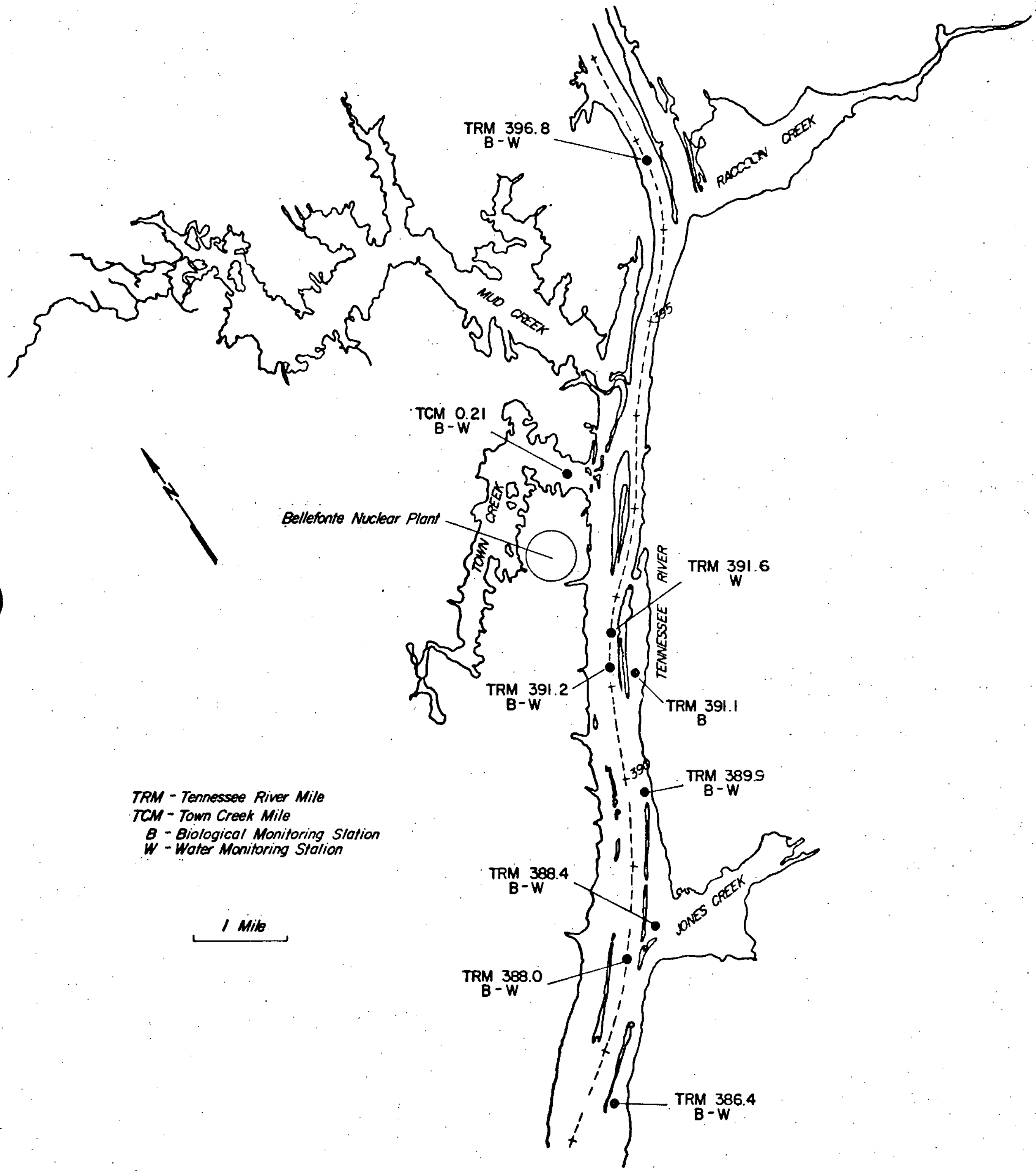
2. At TRM 396.8 during the February-October 1979 surveys, continue collecting only Temperature and DO profile, and TOC, nitrogens (organic, nitrite, nitrate), phosphate (filterable, total), and alkalinity at depths of 0.3, 1, 3, and 5 meters. Stop collecting these samples after the October 1979 survey.

3. At all stations except TRM 396.8, stop collecting all zooplankton, productivity, chlorophyll, phytoplankton cell counts, and periphyton samples.

4. At TRM 396.8, continue to collect the zooplankton and phytoplankton cell counts during the February-October 1979, surveys (periphyton is deleted). Stop collecting these samples after the October 1979 survey.

5. Continue to collect all benthos (dredge and substrate) and sediment samples at all stations throughout the construction phase.

6. Continue to collect the water quality and biological samples identified in table 3.1. Stop collecting these samples after the October 1979 survey.



3.1 Bellefonte Nuclear Plant Preoperational Monitoring Stations for Water Quality and Biological Parameters

4.0 WATER QUALITY STUDIES

Introduction

The water quality of upper Guntersville Reservoir in the vicinity of the site is influenced by several factors: releases from Nickajack Dam, river morphology, regional geology and meteorology, ground water baseflow, land use practices, and waste discharges. The Tennessee River in the site vicinity, from TRM 382.4 (Roseberry Creek) to TRM 416.5 (Alabama-Tennessee state line), is classified by the State of Alabama as suitable for public water supply, swimming and other whole body water-contact sports, and fish and wildlife. The Tennessee River in the vicinity of the site is presently an "effluent limited" stream. An effluent limited stream is one which will meet stream standards after application of secondary treatment for municipalities and best practicable treatment for industries.

The evaluation of water quality in this report is based on data obtained at seven locations in the Tennessee River between TRM 386.4 and TRM 396.8 and one location in the Town Creek embayment, which is tributary to the Tennessee River at approximately TRM 393 (see table 3.1 and figure 3.1). Beginning in February 1974 and continuing through October 1979, water quality samples were collected either monthly or quarterly (depending on parameter) and were analyzed for the parameters identified in table 3.1.

Methods and Materials

The analytical and sample preservation methods used for the chemical water quality characterizations are described in appendix A. Data used in this evaluation were stored on EPA's water quality data storage and retrieval (STORET) system and are available from TVA's Water Quality Branch.

Results

The Tennessee River in the vicinity of BNP is well mixed primarily due to the turbine releases from Nickajack Dam located upstream approximately 28 river miles. However, weak thermal stratification was occasionally observed during low flow in late summer.

Temperature data collected in conjunction with other water quality data and biological samples are summarized in table 4.1. Analytical methods are presented in appendix A. The temperature data were collected primarily for use in interpretation of biological data. The values recorded were instantaneous measurements taken monthly and in some cases quarterly, and thus do not represent overall water temperature conditions in the vicinity of BNP. Temperature data collected during the 1974-1979 monitoring period show a median temperature difference in the water column (surface to bottom) of only 0.1 to 0.2°C. Maximum temperature differences of 0.6°C (TRM 388.4) to 2.9°C (TRM 391.6) were observed during warmer months (May through August) and/or during low flows, evidencing weak thermal stratification (as discussed above). The

Town Creek embayment generally showed greater thermal stratification with water column temperature differences observed as high as 4°C.

Temperature data show that the State of Alabama maximum water temperature criterion of 30°C (86°F) was exceeded by ambient conditions. in Guntersville Reservoir. At TRM 391.6 surface water temperatures during late August 1975 were observed as high as 31.7°C (table 4.1). Mean water temperatures in the site vicinity ranged from 18.8 to 20.6°C (table 4.1). Yearly and seasonal temperature data are summarized in table 4.2 and figure 4.1.

Temperature and dissolved oxygen (DO) measurements made in the Tennessee River in the vicinity of BNP generally parallel temperature and DO measurements made in the tailrace of Nickajack Dam (figures 4.2 through 4.7). For example, in 1978 seasonal temperatures averaged 4.8°C (winter), 18.9°C (spring), 26.7°C (summer), and 15.8°C (fall) in the releases from Nickajack Dam. Corresponding seasonal temperatures in the Tennessee River in the vicinity of BNP averaged 7.5°C (winter), 19.8°C (spring), 25.7°C (summer), and 19.2°C (fall). Seasonal DO measurements in the releases from Nickajack Dam averaged 11.0 mg/1 (winter), 7.0 mg/1 (spring), 5.2 mg/1 (summer), and 7.1 mg/1 (fall). Corresponding seasonal DO measurements in the vicinity of BNP averaged 11.9 mg/1 (winter), 8.0 mg/1 (spring), 6.1 mg/1 (summer), and 7.6 mg/1 (fall).

The State of Alabama water quality criterion for DO specifies that the concentration shall not be less than 5.0 mg/1 (ppm), measured at the 5-foot depth (1.5 meter) or middepth, whichever is less.

Tables 4.1 and 4.3 summarize the DO data collected during the monitoring period. Yearly and seasonal DO data are summarized in figure 4.8 and table 4.3, respectively.

DO concentrations in the vicinity of BNP were observed to fall below the State of Alabama criterion on several occasions. The lowest DO concentrations measured at the 5-foot depth (2.6 mg/l at TRM 391.2, 4.0 mg/l at TRM 396.8, 4.3 mg/l at Town Creek mile (TCM) 0.2, and 4.6 mg/l at TRM 388.0) were all observed on July 28, 1977. During July 1977 the lowest DO concentrations (3.9 mg/l) observed since the closure of Nickajack Dam (figure 4.4) were recorded. Figure 4.9 is a cumulative frequency plot of weekly DO measurements in the Nickajack Dam tailrace. It shows that approximately 5 percent of the time (2-1/2 weeks a year), water released from Nickajack Dam has concentrations of DO less than or equal to 5 mg/l.

Vertical DO profiles in upper Guntersville Reservoir often show surface concentrations 3.0 mg/l higher than bottom concentrations. This often appears to be related to releases of cool, low DO water from Nickajack Dam during the summer months. However, median DO differences (surface-bottom) only vary between 0.2 and 0.4 mg/l (table 4.1).

High pH values (>8.5) and high DO values (>120 percent saturation) were recorded simultaneously during the summer months at shallow overbank and embayment sampling locations, indicating high photosynthetic activity. The applicable State of Alabama criteria for pH is a range from 6.0 to 8.5. EPA's Secondary Drinking Water Standards (for finished water) recommend a range from 6.5 to 8.5. During the monitoring period, pH values ranged from 6.1 to 9.0. The pH data are summarized in tables 4.4, 4.5, and 4.6.

Total alkalinity in samples collected during the monitoring program ranged from 14 to 74 mg/l as $CaCO_3$, with a mean of 51 mg/l, which indicates a moderate buffering capacity, predominately by bicarbonates (HCO^-_3). The hardness of the water ranged from 45 to 97 mg/l as $CaCO_3$, with a mean hardness of 65 mg/l. Waters with this degree of hardness are generally categorized as soft to moderately hard. Dissolved solids concentrations were low and averaged 94 mg/l. The observed values of alkalinity, hardness, and dissolved solids are typical of Tennessee River water. These data are summarized in tables 4.4, 4.5, and 4.6.

The results of the trace metal and other water quality parameters monitored during the preoperational program are also summarized in tables 4.4, 4.5, and 4.6. Also shown in the tables are the criteria guidelines recommended in EPA's Primary Drinking Water Standards (for finished water), Secondary Drinking Water Standards (for finished water), and Quality Criteria for Water. The Primary Drinking Water Standards are health standards, i.e., the ingestion of "high" levels of these contaminants has been shown to cause, or has been implicated in the cause of, some types of health problems. From a total of 1387 measurements on ten parameters (nitrate nitrogen, fluoride, arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) which are listed in the Primary Standards, only one measurement (mercury 4.1 μg/l, May 8, 1974, at TRM 396.8) exceeded its respective standard (2 μg/l standard) and 99 of the 116 mercury measurements were below the limit of detection (0.2 μg/l). In summary, the reservoir water quality generally meets the National Primary Drinking Water Standards.

Secondary Drinking Water Standards are aesthetic standards, i.e., high levels of these parameters result in undesirable taste, color, or odor. The mean values for total iron (465 μg/l) and manganese (60 μg/l) are substantially above their respective Secondary Standards (300 μg/l and 50 μg/l, respectively). However, total dissolved iron and manganese averaged only 63 μg/l and 16 μg/l, respectively, indicating that approximately 85 percent of the iron and 70 percent of the manganese concentrations are associated with suspended solids and can be easily removed by conventional filtration methods. High turbidity and suspended solids values were associated with high total iron and manganese concentrations. True color exceeded its standard (15 PCU) 43 times out of 236 measurements. All measurements of chloride, copper, sulfate, and zinc (total of 611) were well below their respective Secondary Standards.

A comparison of the remaining data in tables 4.4, 4.5, and 4.6 to EPA's Quality Criteria for Water (1976) indicates that observed concentrations of beryllium, boron, and other trace contaminants (not included in the National Primary and Secondary Standards) were well below the listed EPA criteria. The concentrations of total and fecal coliforms, BOD_5, COD, and TOC indicate that the bacteriological and sanitary quality easily met the guidelines recommended by EPA.

Summary

Maximum instantaneous water temperatures measured in the vicinity of BNP were found to naturally exceed the State of Alabama criterion of 30°C during the late summer. Concentrations of DO were occasionally found to be less than the State criterion of 5.0 mg/l. Both temperature and DO excursions from State standards are influenced by the release of water from Nickajack Dam. The pH values exceeding 8.5 were often attributable to high photosynthetic activity.

Total alkalinity concentrations averaged 51 mg/l, which indicates a limited buffering capacity. Chemical quality of the water in upper Guntersville Reservoir was very good as mean values of all parameters listed in the National Primary Drinking Water Standards and in EPA's *Quality Criteria for Water* were met.

Table 4.1

SUMMARY OF PREOPERATIONAL SURVEY OF TEMPERATURE AND DISSOLVED OXYGEN DATA IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT, 1974-1979

Location	Temperature (°C) Min	Mean	Max	Total number of observations	Vertical difference (°C) (top to bottom) Min	Median	Max	Maximum depth (ft)	Horizontal location (%)
TRM 386.4	5.0	20.6	27.5	97	-0.2	0.1	0.7	7	1 and 99
TRM 388.0	3.9	19.8	29.5	289	-0.5	0.1	1.3	30	30 and 80
TRM 388.4	5.7	19.6	28.5	81	-0.1	0.1	0.6	6	1
TRM 389.8	4.5	20.4	28.0	413	-0.1	0.2	0.7	30	5
TRM 391.2	4.0	19.7	28.9	331	-1.1	0.1	1.7	26	60 and 1
TRM 391.6	4.8	18.8	31.7	48	-0.1	0.1	2.9	10	95
TRM 396.8	4.0	19.5	28.8	320	-0.3	0.1	1.3	30	50
TCM 0.2	4.9	20.5	29.0	146	-1.0	0.1	4.0	13	50
All locations	3.9	19.9	31.7	1725	-1.1	0.1	4.0	-	-

Location	Dissolved oxygen (mg/l) Min	Mean	Max	Min at 5 ft*	Total number of observations	Vertical difference (°C) (top to bottom) Min	Median	Max	Maximum depth (ft)	Horizontal location (%)
TRM 386.4	4.2	7.9	11.1	5.3	97	-0.3	0.3	2.5	7	1 and 99
TRM 388.0	2.1	7.6	14.0	4.6	284	-0.3	0.2	3.2	30	30 and 80
TRM 388.4	6.0	8.7	10.9	6.6	81	-0.3	0.2	2.1	7	1
TRM 389.8	5.4	7.6	11.8	5.6	413	0.1	0.3	0.8	30	5
TRM 391.2	1.1	7.6	13.7	2.6	331	-1.3	0.2	3.0	26	60 and 1
TRM 391.6	4.6	8.3	14.0	4.6	48	0.0	0.3	1.8	10	95
TRM 396.8	1.7	7.4	13.8	4.0	312	-0.9	0.2	3.3	30	50
TCM 0.2	3.4	7.8	14.4	4.3	143	-0.3	0.4	2.4	13	50
All locations	1.1	7.7	14.4	2.6	1709	-1.3	0.3	3.3	-	-

* Where maximum depth is less than 10 feet, data represent middepth samples.

Table 4.2

SUMMARY OF AVERAGE QUARTERLY TEMPERATURE (°C) - GUNTERSVILLE RESERVOIR BELLEFONTE PREOPERATIONAL MONITORING SURVEYS,[a] 1974-1979

		Tennessee River Mile[b]							Town Creek
Year	Season	386.4	388.0	388.4	389.8	391.2	391.6	396.8	Mile 0.2
1974	Winter[c]	-	10.6	-	-	10.6	11.0	10.5	12.4
	Spring	-	18.1	-	-	18.4	18.8	17.8	20.2
	Summer	-	26.0	-	-	24.3	25.3	25.1	25.8
	Fall	-	21.0	-	-	21.2	21.1	21.5	21.5
1975	Winter	-	10.0	-	-	10.1	11.6	10.3	12.8
	Spring	-	20.3	-	-	20.1	24.4	20.0	20.8
	Summer	-	25.6	-	-	24.0	29.8	25.5	25.2
	Fall	-	17.6	-	-	17.9	17.6	18.0	17.5
1976	Winter	-	11.2	-	-	11.2	10.4	11.5	12.9
	Spring	-	20.3	-	-	20.6	19.2	20.7	20.4
	Summer	-	25.5	-	-	25.4	25.8	25.3	25.2
	Fall	-	17.8	-	-	18.0	18.0	18.3	18.0
1977	Winter	-	8.2	-	-	7.5	5.0	8.0	10.3
	Spring	-	21.9	-	-	21.1	22.8	20.9	22.7
	Summer	-	26.4	-	-	25.3	24.8	25.4	25.4
	Fall	-	13.8	-	-	13.8	13.5	16.9	16.3
1978	Winter	10.3	6.8	9.6	9.5	7.6	4.9	7.1	8.0
	Spring	19.8	19.7	18.9	20.5	19.6	17.5	18.8	20.6
	Summer	27.0	27.0	25.9	25.1	25.9	24.8	25.3	26.2
	Fall	19.1	19.9	14.2	19.7	18.3	19.9	19.5	19.7
1979	Winter	8.3	-	8.2	7.2	8.6	-	8.3	-
	Spring	20.9	-	20.7	20.9	21.5	-	20.2	-
	Summer	25.0	-	25.0	24.9	25.4	-	24.9	-
	Fall	18.0	-	16.1	18.1	15.0	-	18.0	-

a. The numbers in this table represent averages of temperatures at all depths.

b. For detailed information on temperature (and dissolved oxygen) measurements in the releases from Nickajack Dam (TRM 424.7), please refer to figures 4.1 through 4.6.

c. Winter (January, February, and March); Spring (April, May, and June); Summer (July, August, and September); Fall (October, November, and December).

Table 4.3

SUMMARY OF AVERAGE QUARTERLY DISSOLVED OXYGEN (mg/l) - GUNTERSVILLE RESERVOIR
BELLEFONTE PREOPERATIONAL MONITORING SURVEYS,[a] 1974-1979

Year	Season	Tennessee River Mile[b] 386.4	388.0	388.4	389.8	391.2	391.6	396.8	Town Creek Mile 0.2
1974	Winter[c]	-	11.1	-	-	11.2	11.5	10.9	9.0
	Spring	-	7.7	-	-	7.8	8.2	7.4	8.5
	Summer	-	5.8	-	-	6.1	6.3	5.8	6.2
	Fall	-	6.4	-	-	7.2	8.9	6.7	8.0
1975	Winter	-	11.2	-	-	11.0	9.6	11.3	9.4
	Spring	-	7.4	-	-	7.6	4.8	7.5	8.1
	Summer	-	5.7	-	-	6.1	6.8	5.7	6.8
	Fall	-	7.7	-	-	7.1	8.5	7.1	9.9
1976	Winter	-	10.0	-	-	10.0	9.9	10.0	11.3
	Spring	-	7.2	-	-	7.1	7.2	6.8	6.9
	Summer	-	6.1	-	-	6.0	6.3	5.9	5.7
	Fall	-	7.7	-	-	7.8	7.6	7.6	7.7
1977	Winter	-	11.6	-	-	11.6	13.4	9.1	10.7
	Spring	-	7.0	-	-	6.9	6.7	6.8	7.4
	Summer	-	4.9	-	-	4.0	6.0	4.5	4.7
	Fall	-	8.4	-	-	8.3	9.1	7.9	9.3
1978	Winter	10.8	12.3	10.6	10.7	11.7	13.2	12.1	12.4
	Spring	8.5	8.1	8.9	7.7	8.2	9.0	7.7	9.3
	Summer	5.6	5.9	7.9	5.9	6.2	6.7	6.0	6.7
	Fall	7.8	7.7	9.2	7.3	7.8	7.8	7.2	7.5
1979	Winter	10.6	-	10.4	10.7	11.0	-	10.5	-
	Spring	8.3	-	8.5	8.0	8.5	-	8.2	-
	Summer	6.8	-	7.8	6.4	7.0	-	6.6	-
	Fall	8.3	-	9.3	8.1	8.4	-	8.3	-

a. The numbers in this table represent averages of dissolved oxygen measurements at all depths.

b. For detailed information on dissolved oxygen (and temperature) measurements in the releases from Nickajack Dam (TRM 424.7), please refer to figures 4.1 through 4.6.

c. Winter (January, February, and March); Spring (April, May, and June); Summer (July, August, and September); Fall (October, November, and December).

Table 4.4

SUMMARY OF WATER QUALITY DATA - GUNTERSVILLE RESERVOIR
TENNESSEE RIVER MILES 388.0 AND 391.2
1974-1979

	Tennessee River Mile 388.0				Tennessee River Mile 391.2				
Parameter	Number of samples	Mean	Max	Min	Number of samples	Mean	Max	Min	Criteria concentration
Turbidity, JTU	97	8.4	35.0	1.5	79	8.7	32.0	1.4	
Color, PCU	72	11.8	36.0	4.0	62	10.9	33.0	3.0	15[a]
Apparent color, PCU	70	24.2	65.0	10.0	60	21.6	80.0	8.0	
Conductivity @ 25°C, μmhos/cm	271	166.0	280	88	300	163.4	210	75	
BOD_5, mg/l	68	1.2	2.3	<1.0	50	1.1	1.6	<1.0	
COD, mg/l	41	5.1	13.0	2.0	33	5.5	31.0	2.0	
pH, Standard Units	282	7.2	7.9	6.1	312	7.3	8.6	6.2	6.5-8.5[a]
Total alkalinity as $CaCO_3$, mg/l	113	51.1	62.0	36.0	115	50.5	67.0	14.0	
Suspended solids, mg/l	95	6.7	37.0	<1.0	79	6.9	38.0	<1.0	
Dissolved solids, mg/l	66	94.5	150.0	70.0	49	90.8	150.0	60.0	500[a]
Total volatile solids, %	57	3.9	6.1	2.0	2	1.9	2.1	1.8	
Organic nitrogen, mg/l	103	0.12	0.34	<0.02	102	0.13	0.29	<0.02	
NH_3+NH_4-N, mg/l	103	0.07	0.30	0.01	89	0.07	0.16	0.1	
NO_2+NO_3-N, mg/l	103	0.36	1.10	0.11	102	0.34	0.75	<0.01	10.0[b]
Phosphorus, total, mg/l	103	0.03	0.06	0.02	102	0.04	0.11	0.01	
Phosphorus, dissolved, mg/l	73	0.07	0.78	<0.01	81	0.04	0.73	<0.01	
Total organic carbon, mg/l	77	2.3	9.2	1.0	84	2.4	7.6	0.2	
Calcium, mg/l	77	18.7	25.0	14.0	70	18.5	25	13	
Magnesium, mg/l	77	4.3	8.3	3.0	70	4.3	8.3	3.1	
Hardness, as $CaCO_3$, mg/l	77	64.3	92	47	70	63.9	89	46	
Sodium, mg/l	40	5.6	8.5	3.0	32	5.7	8.6	3.4	
Potassium, mg/l	40	1.3	1.7	0.8	32	1.3	1.6	0.8	
Chloride, mg/l	77	6.9	11.0	4.0	67	6.8	11.0	4.0	250[a]
Sulfate, mg/l	39	13.2	21.0	4.0	32	12.9	19.0	9.0	250[a]
Fluoride, mg/l	11	0.09	0.10	<0.05	4	<0.10	<0.10	<0.10	1.4[b,d]

Table 4.4 (continued)

Parameter	Tennessee River Mile 388.0 Number of samples	Mean	Max	Min	Tennessee River Mile 391.2 Number of samples	Mean	Max	Min	Criteria concentration
Silica, dissolved, mg/l	33	4.9	5.9	4.0	32	4.8	5.7	4.0	
Silica, total, mg/l	6	6.4	8.1	5.1	-	-	-	-	
Aluminum, µg/l	38	478.2	2300	180	30	466.7	1200	200	
Arsenic, µg/l	38	3.6	6	<2	30	3.7	8	<2	50[b]
Barium, µg/l	38	117.1	320	<100	30	113.7	320	<100	1000[b]
Beryllium, µg/l	38	<10.0	<10	<10	30	<10.0	<10	<10	11[c]
Boron, µg/l	38	91.1	270	<10	29	100.3	420	20	750[c]
Cadmium, µg/l	38	<1.0	<1	<1	30	<1.0	<1	<1	10[b]
Chromium, µg/l	38	5.5	24	<5	30	5.3	14	<5	50[b]
Copper, µg/l	38	38.9	130	<10	30	36.3	100	<10	1000[a]
Iron, total, µg/l	75	463.1	2500	<50	67	442.4	2000	<50	300[a],1000[c]
Iron, dissolved, µg/l	72	67.1	220	<50	65	60.9	360	<50	
Iron, ferrous, µg/l	77	91.2	280	<10	69	91.1	270	<20	
Lead, µg/l	38	12.0	35	<10	30	10.2	15	<10	50[b]
Lithium, µg/l	37	<10.0	<10	<10	30	<10.0	<10	<10	
Manganese, total, µg/l	44	56.6	320	10	36	54.4	250	20	50[a], 100[c]
Manganese, dissolved, µg/l	44	15.0	40	<10	36	14.4	60	<10	
Mercury, µg/l	38	0.26	1.10	<0.20	30	0.21	0.40	<0.20	2[b]
Nickel, µg/l	38	52.9	340	<10	30	43.0	110	<10	
Selenium, µg/l	37	1.4	2	<1	30	1.3	2	<1	10[b]
Silver, µg/l	38	10.3	20	<10	30	<10.0	<10	<10	50[b]
Titanium, µg/l	38	<1000.0	<1000	<1000	30	<1000.0	<1000	<1000	
Zinc, µg/l	38	33.7	220	<10	30	34.3	210	<10	5000[a]
Total coliforms (number/100 ml)	15	110.0	480	<10	10	156.5	670	<10	
Fecal coliforms (number/100 ml)	30	44.0	320	<10	21	24.5	150	<10	

a. National Secondary Drinking Water Standards.
b. National Primary Drinking Water Standards.
c. USEPA Quality Criteria for Water, 1976.
d. Maximum level based on daily air temperatures.

Table 4.5

SUMMARY OF WATER QUALITY DATA - GUNTERSVILLE RESERVOIR
TENNESSEE RIVER MILE 396.8 AND TOWN CREEK MILE 0.2
1974-1979

Parameter	Tennessee River Mile 396.8				Town Creek Mile 0.2				Criteria concentration
	Number of samples	Mean	Max	Min	Number of samples	Mean	Max	Min	
Turbidity, JTU	76	8.4	31.0	1.6	44	9.8	48.0	2.4	
Color, PCU	69	10.2	36	1	29	10.6	34	1	15[a]
Apparent color, PCU	61	22.1	75	8	28	25.3	88	12	
Conductivity @ 25°C, μmhos/cm	302	162.3	200	95	138	165.7	200	100	
BOD_5, mg/l	48	1.2	1.9	<1.0	22	1.4	3.2	<1.0	
COD, mg/l	41	5.3	17	1	15	7.7	19	4	
pH, Standard Units	315	7.2	8.5	6.2	143	7.5	9.0	6.2	6.5-8.5[a]
Total alkalinity as $CaCO_3$, mg/l	133	50.9	65	35	47	56.4	74	41	
Suspended solids, mg/l	76	7.3	39	<1	37	10.6	31	3	
Dissolved solids, mg/l	45	92.7	180	70	22	100.5	150	70	500[a]
Total volatile solids, %	3	2.0	2.9	1.4	30	6.9	10.2	3.9	
Organic nitrogen, mg/l	117	0.10	0.38	0.01	40	0.17	0.33	0.03	
NH_3+NH_4-N, mg/l	89	0.07	0.15	0.02	40	0.05	0.11	0.01	
NO_2+NO_3-N, mg/l	117	0.37	0.68	0.26	40	0.26	1.60	<0.01	10.0[b]
Phosphorus, total, mg/l	117	0.03	0.07	0.01	40	0.03	0.07	0.01	
Phosphorus, dissolved, mg/l	106	0.03	0.66	<0.01	30	0.02	0.11	<0.01	
Total organic carbon, mg/l	105	2.3	6.6	0.4	33	2.5	6.2	1.3	
Calcium, mg/l	75	18.8	32	13	32	20.1	25	14	
Magnesium, mg/l	75	4.3	8.5	2.8	32	4.1	7.8	2.6	
Hardness, as $CaCO_3$, mg/l	75	64.8	97	45	32	67.2	87	49	
Sodium, mg/l	38	5.5	8.6	2.4	14	5.0	8.4	2.3	
Potassium, mg/l	38	1.3	1.8	0.8	14	1.2	1.5	0.6	
Chloride, mg/l	73	6.8	11	4	31	6.3	11	4	250[a]
Sulfate, mg/l	38	12.3	19	7	14	11.5	15	8	250[a]
Fluoride, mg/l	21	0.09	0.10	<0.05	2	<0.10	<0.10	<0.10	1.4[b,d]

Table 4.5 (continued)

Parameter	Tennessee River Mile 396.8 Number of samples	Mean	Max	Min	Town Creek Mile 0.2 Number of samples	Mean	Max	Min	Criteria concentration
Silica, dissolved, mg/l	32	4.9	5.7	4.1	16	4.3	6.4	2.0	
Silica, total, mg/l	5	6.0	7.6	4.9	–	–	–	–	
Aluminum, µg/l	36	503.1	2100	200	13	380.0	700	200	
Arsenic, µg/l	35	3.8	10	<2	13	3.2	5	<2	50[b]
Barium, µg/l	36	111.1	310	<100	13	<100.0	<100	<100	1000[b]
Beryllium, µg/l	35	<10.0	<10	<10	13	<10.0	<10	<10	11[c]
Boron, µg/l	36	86.7	200	<10	13	78.5	180	<10	750[c]
Cadmium, µg/l	35	1.0	1	<1	13	1.2	4	<1	10[b]
Chromium, µg/l	36	5.0	6	<5	13	5.0	5	<5	50[b]
Copper, µg/l	36	36.1	150	<10	13	38.5	90	<10	1000[a]
Iron, total, µg/l	73	445.2	2000	<50	31	509.7	1700	140	300[a], 1000[c]
Iron, dissolved, µg/l	70	60.1	150	<50	30	66.3	380	<50	
Iron, ferrous, µg/l	75	94.8	320	<10	33	113.5	280	20	
Lead, µg/l	36	10.6	30	<10	13	<10.0	<10	<10	50[b]
Lithium, µg/l	35	<10.0	<10	<10	13	<10.0	<10	<10	
Manganese, total, µg/l	43	59.3	370	20	16	80.0	180	30	50[a], 100[c]
Manganese, dissolved, µg/l	43	14.4	50	<10	16	24.4	60	<10	
Mercury, µg/l	36	0.4	4.1	<0.2	13	0.2	0.5	<0.2	2[b]
Nickel, µg/l	36	44.4	70	<10	13	40.8	50	<10	
Selenium, µg/l	34	1.4	4	<1	13	1.2	2	<1	10[b]
Silver, µg/l	36	<10.0	<10	<10	13	<10.0	<10	<10	50[b]
Titanium, µg/l	36	<1000.0	<1000	<1000	13	<1000.0	<1000	<1000	
Zinc, µg/l	36	24.7	50	<10	13	24.6	60	<10	5000[a]
Total coliforms (number/100 ml)	18	458.6	2000	<10	8	48.8	170	<10	
Fecal coliforms (number/100 ml)	21	31.4	170	<10	18	32.8	220	<10	

a. National Secondary Drinking Water Standards.
b. National Primary Drinking Water Standards.
c. USEPA Quality Criteria for Water, 1976.
d. Maximum level based on daily air temperatures.

Table 4.6

SUMMARY OF WATER QUALITY DATA - GUNTERSVILLE RESERVOIR
TENNESSEE RIVER MILES 386.4, 388.4 AND 391.6
1974-1979

Parameter	Tennessee River Mile 386.4				Tennessee River Mile 388.4				Tennessee River Mile 391.6				Criteria concentrations
	Number of samples	Mean	Max	Min	Number of samples	Mean	Max	Min	Number of samples	Mean	Max	Min	
Conductivity @ 25°C, μmhos/cm	97	155.6	200	90	81	151.4	200	70	45	169.3	220	130	
pH, Standard Units	97	7.3	7.9	6.7	81	7.7	8.7	6.9	46	7.3	8.3	6.3	6.5-8.5[a]
Total alkalinity as $CaCO_3$, mg/l	17	15.1	69	34	17	53.0	69	44	22	52.9	61	43	
Organic nitrogen, mg/l	17	0.12	0.24	0.04	17	0.11	0.25	0.04	22	0.12	0.20	0.04	
NH_3+NH_4-N, mg/l	3	0.08	0.15	0.04	3	0.08	0.13	0.05	21	0.06	0.15	<0.01	
NH_2+NO_4-N, mg/l	17	0.37	0.79	0.14	17	0.23	0.62	<0.01	22	0.30	0.56	0.01	10.0[b]
Phosphorus, total, mg/l	17	0.03	0.08	0.01	17	0.03	0.08	0.01	22	0.04	0.19	0.01	
Phosphorus, dissolved, mg/l	17	0.01	0.03	<0.01	17	0.02	0.06	<0.01	1	<0.01	<0.01	<0.01	
Total organic carbon, mg/l	16	2.9	4.8	1.6	16	3.0	4.3	2.2	1	3.3	3.3	3.3	
Turbidity, JTU	-	-	-	-	-	-	-	-	21	12.3	65	2	
Color, PCU	-	-	-	-	-	-	-	-	4	13.0	20	7	15[a]
Apparent color, PCU	-	-	-	-	-	-	-	-	4	21.8	32	12	
BOD_5, mg/l	-	-	-	-	-	-	-	-	21	1.3	3.4	<1.0	
Suspended solids, mg/l	-	-	-	-	-	-	-	-	21	27.9	410	2	
Dissolved solids, mg/l	-	-	-	-	-	-	-	-	21	97.6	180	80	500[a]
Total volatile solids, %	-	-	-	-	-	-	-	-	32	6.3	8.4	5.1	
Chloride, mg/l	-	-	-	-	-	-	-	-	3	7.3	10	4	250[a]
Sulfate, mg/l	-	-	-	-	-	-	-	-	3	12.7	15	9	250[a]
Total coliforms (number/100 ml)	-	-	-	-	-	-	-	-	6	291.7	980	10	
Fecal coliforms (number/100 ml)	-	-	-	-	-	-	-	-	11	41.8	240	10	

a. National Secondary Drinking Water Standards.
b. National Primary Drinking Water Standards.
c. USEPA Quality Criteria for Water, 1976.
d. Maximum level based on daily air temperatures.

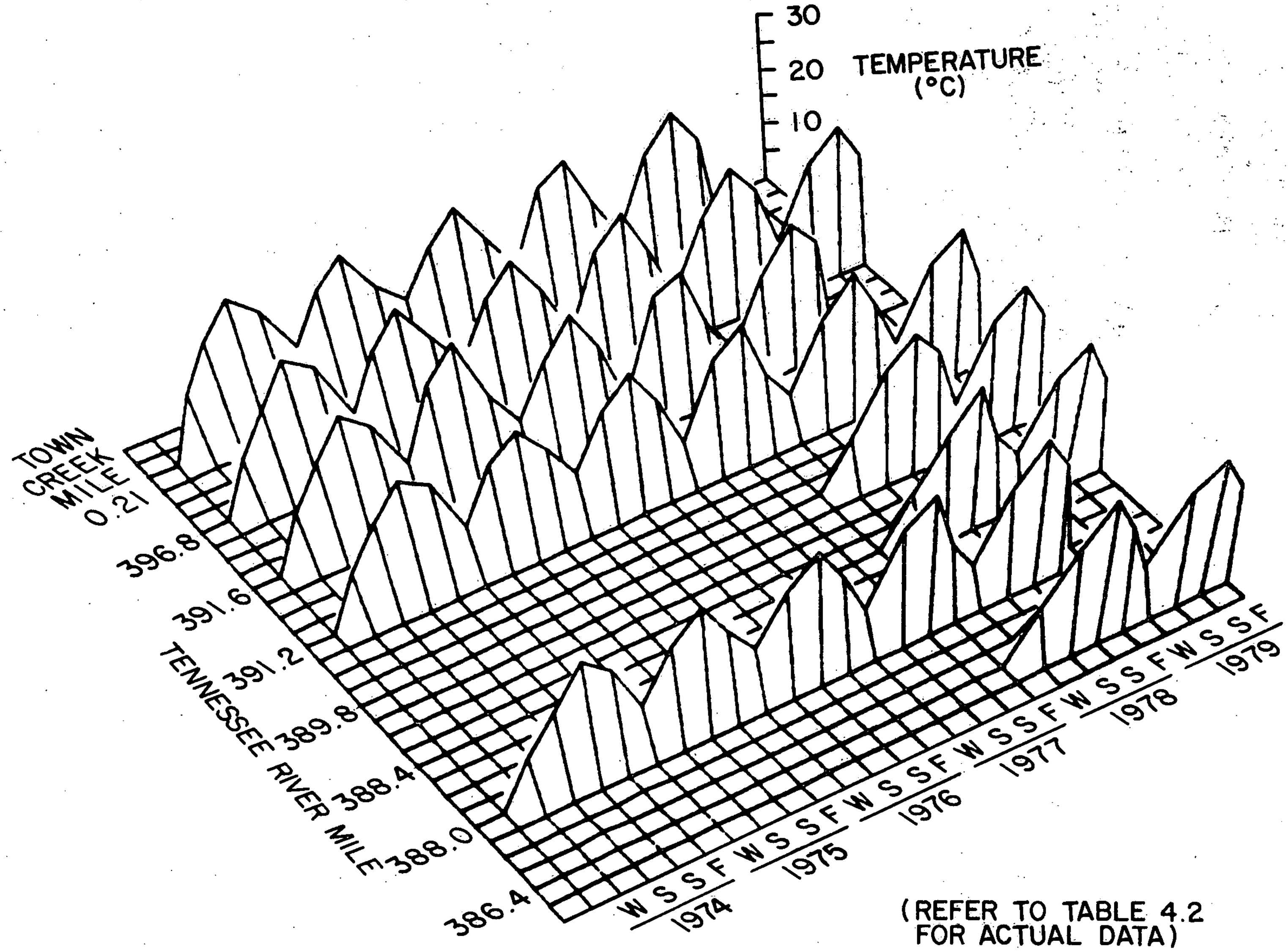
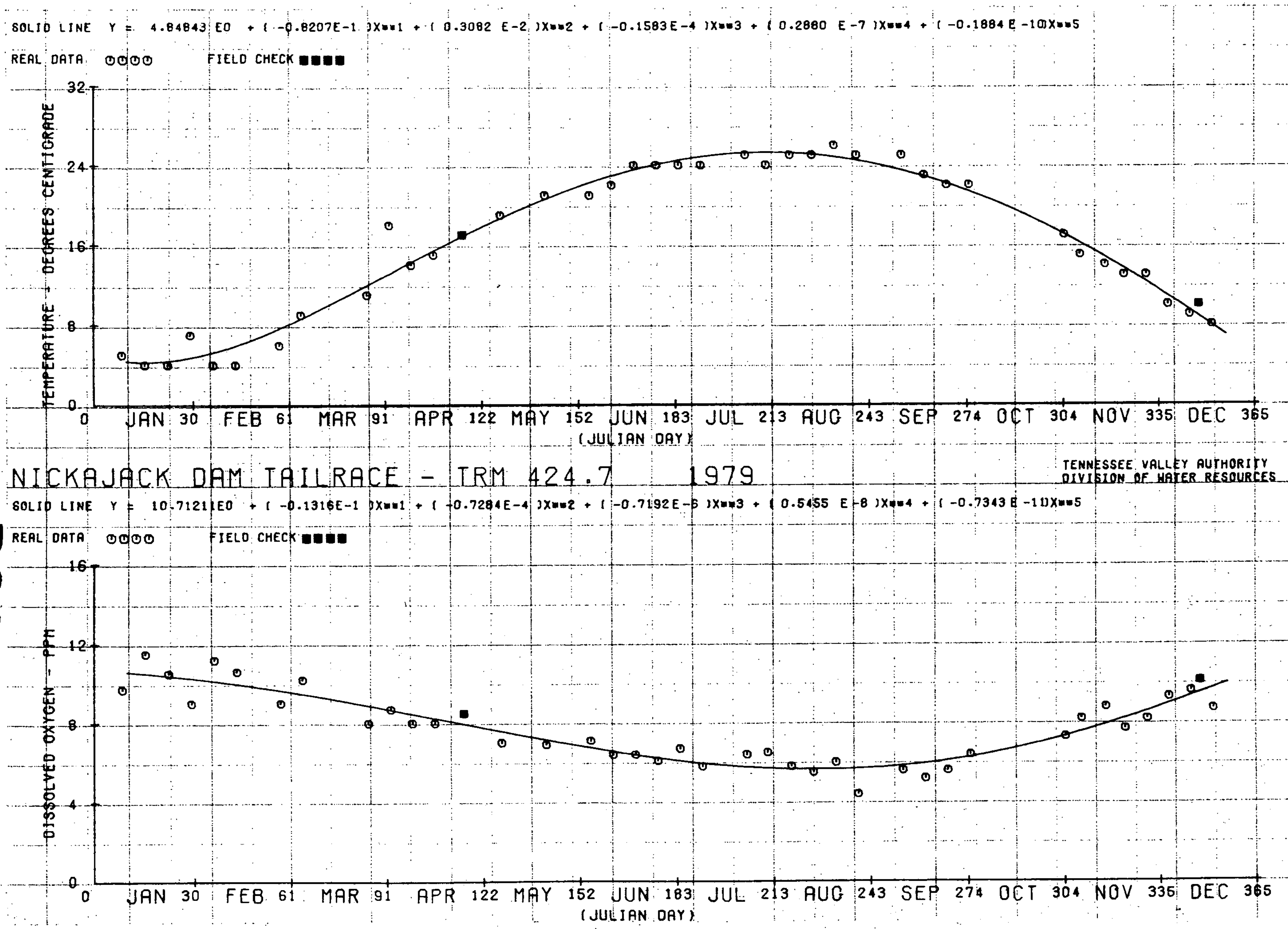


Figure 4.1 Quarterly Averaged Temperature Data in the Vicinity of the Bellefonte Nuclear Plant, 1974-1979



POOR ORIGINAL

Figure 4.2 Temperature and Dissolved Oxygen Data for Releases from Nickajack Dam - 1979

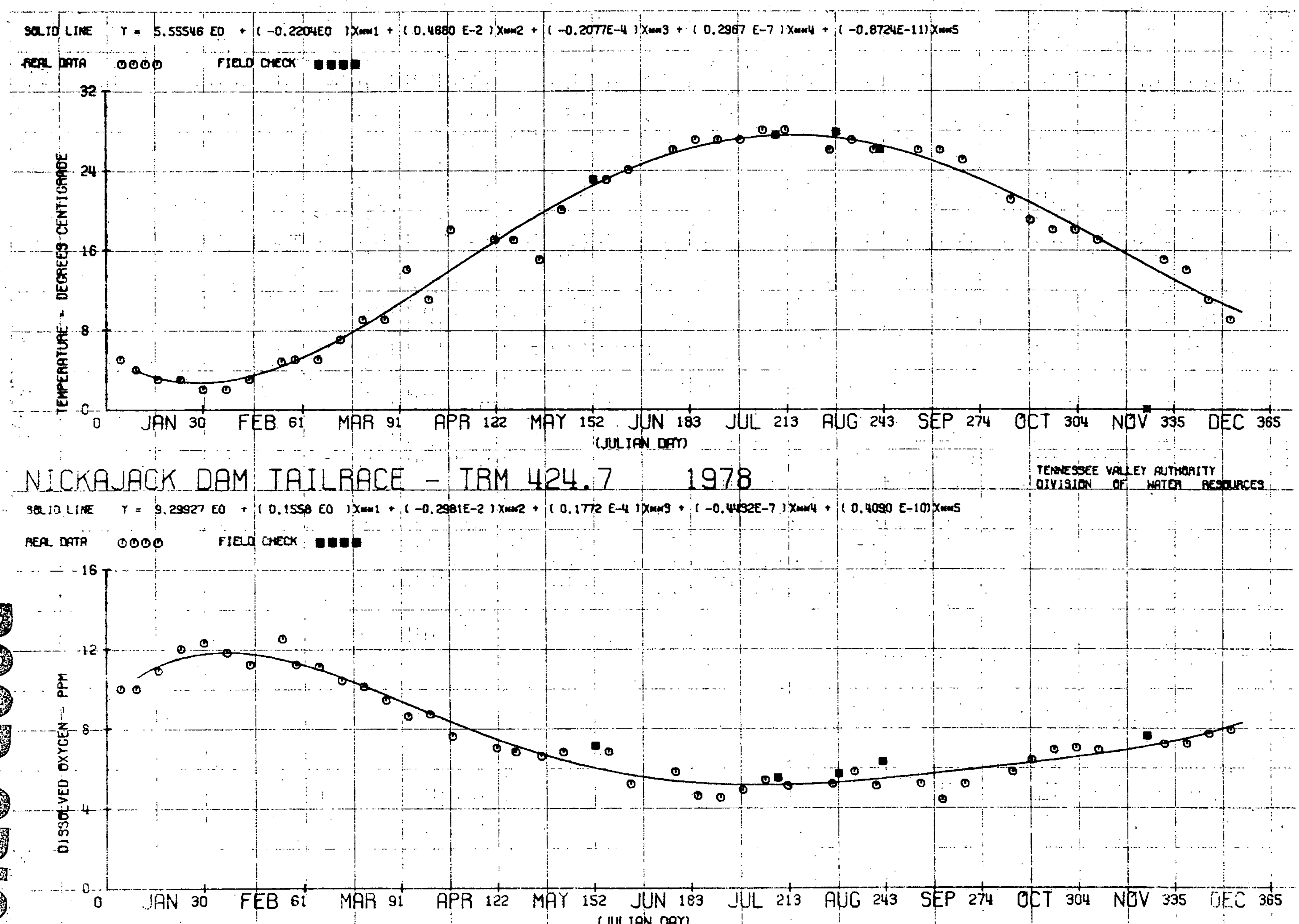


Figure 4.3 Temperature and Dissolved Oxygen Data for Releases from Nickajack Dam - 1978

POOR ORIGINAL

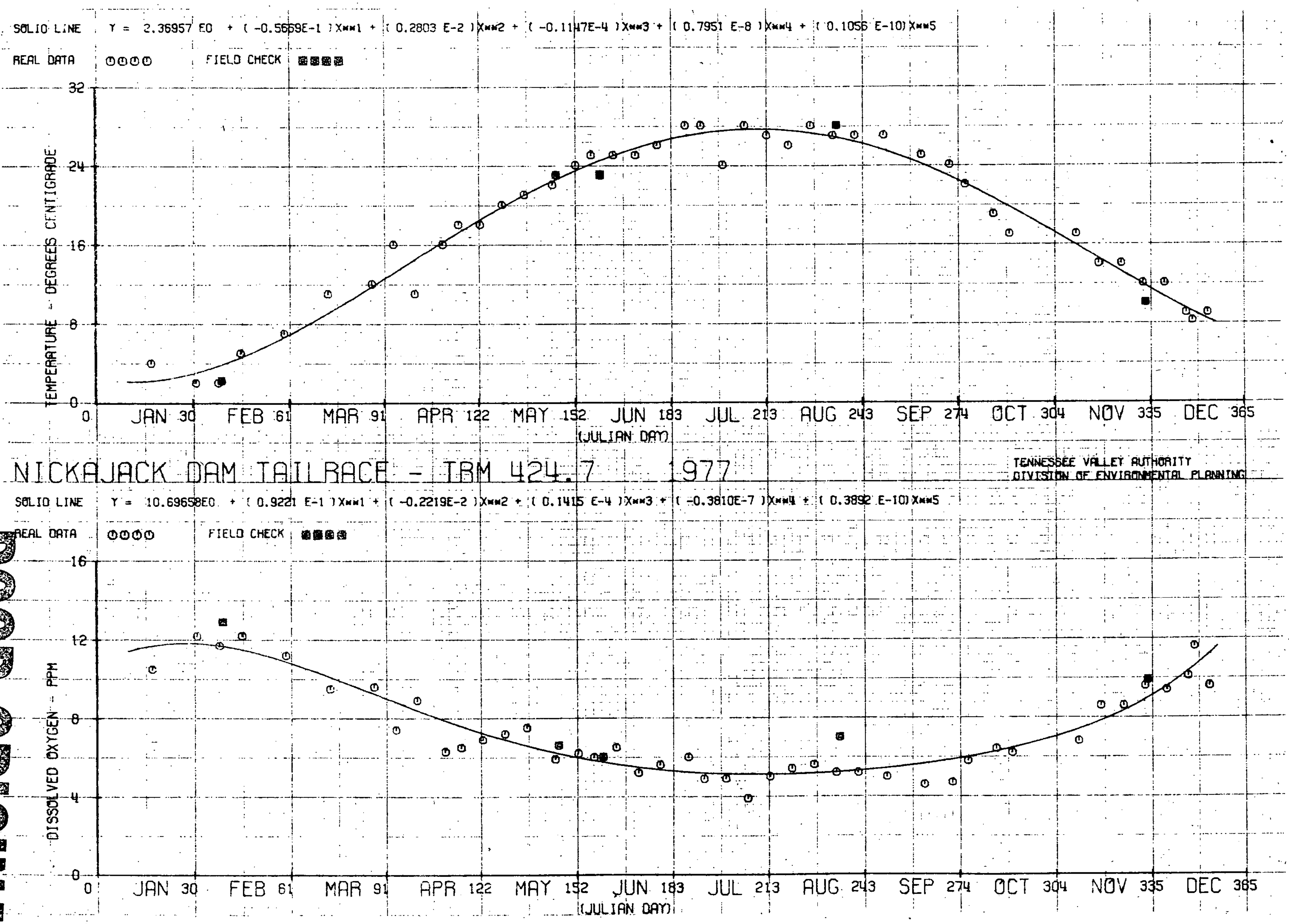


Figure 4.4 Temperature and Dissolved Oxygen Data for Releases from Nickajack Dam - 1977

POOR ORIGINAL

POOR ORIGINAL

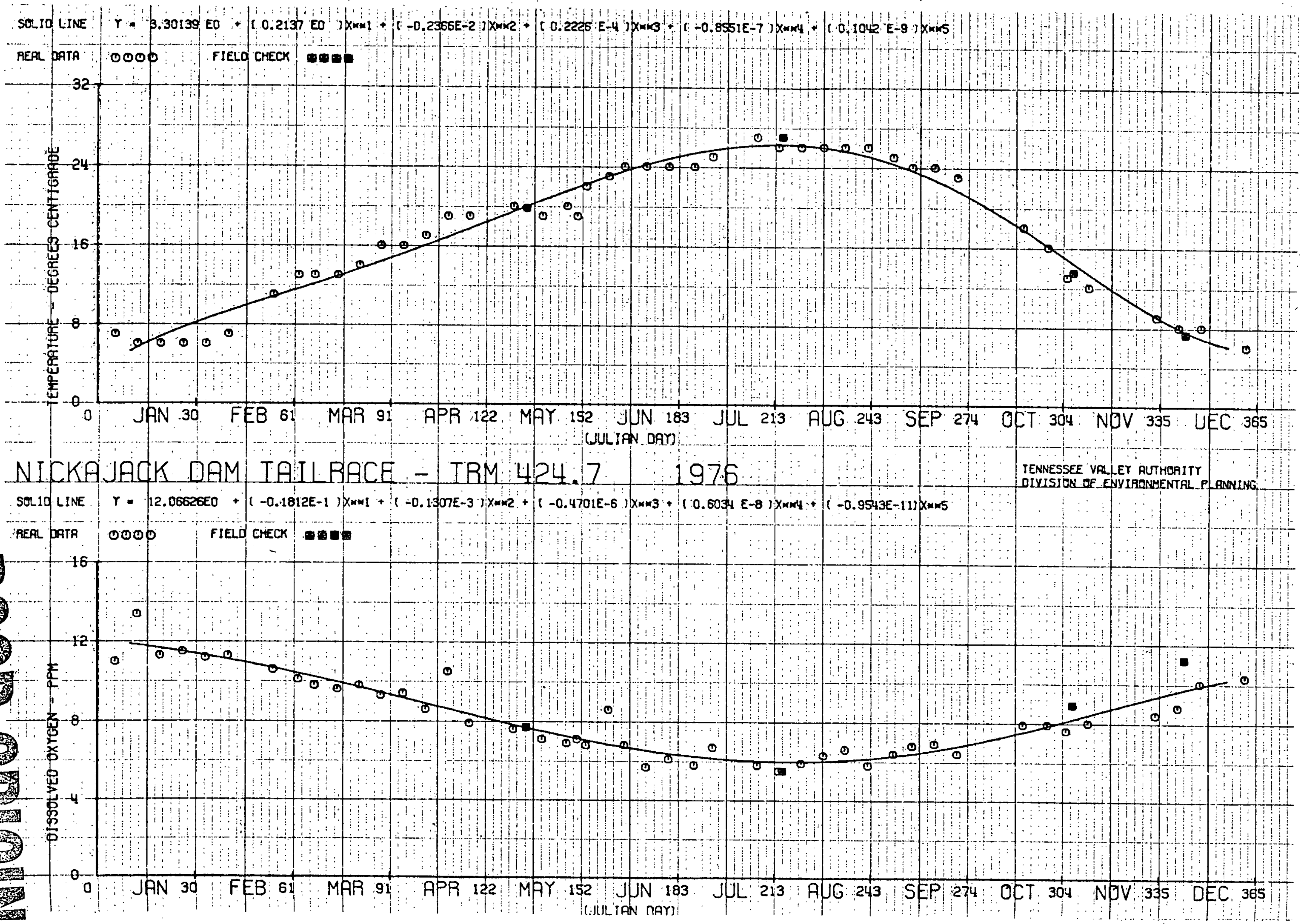


Figure 4.5 Temperature and Dissolved Oxygen Data for Releases from Nickajack Dam - 1976

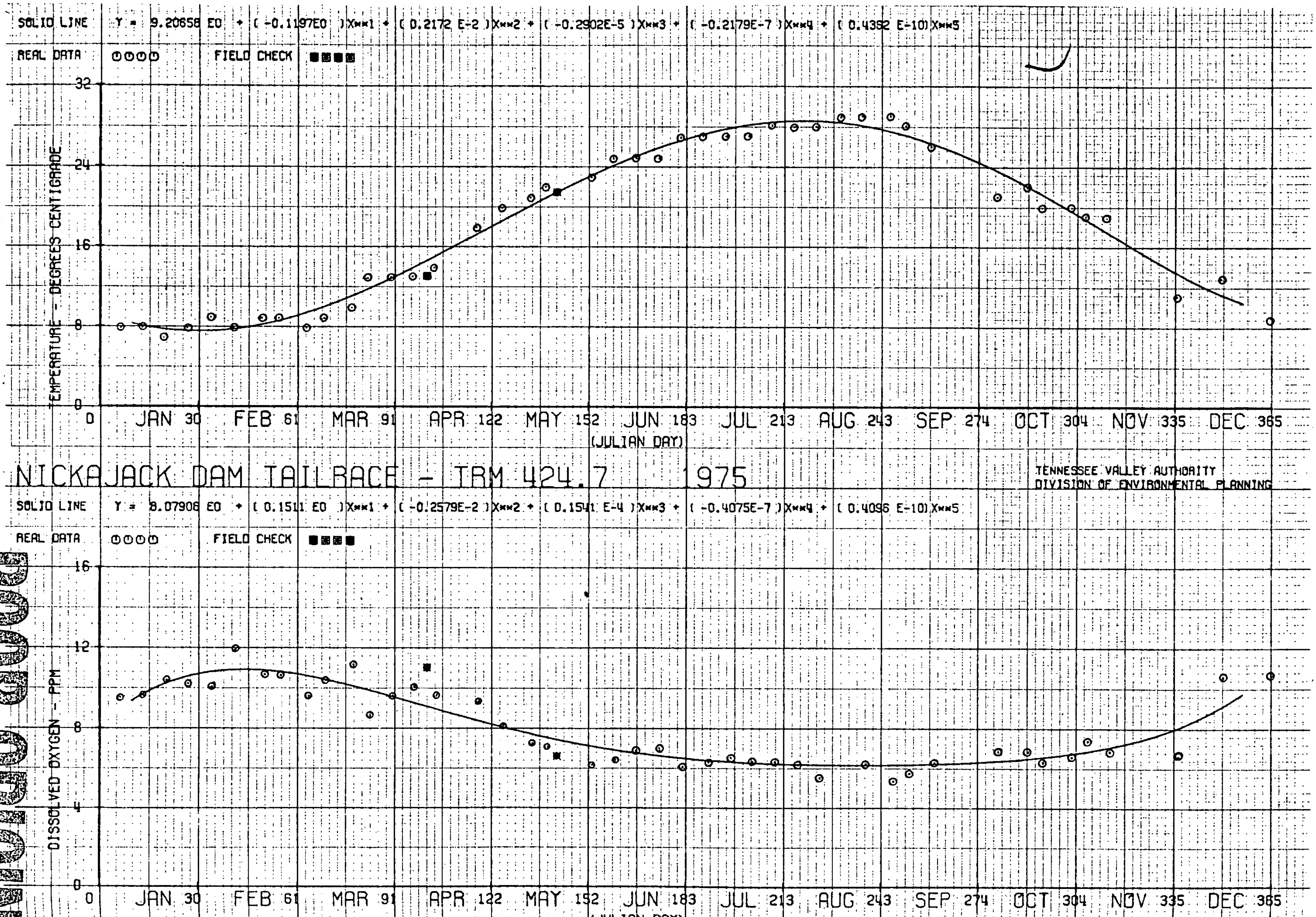


Figure 4.6 Temperature and Dissolved Oxygen Data for Releases from Nickajack Dam - 1975

POOR ORIGINAL

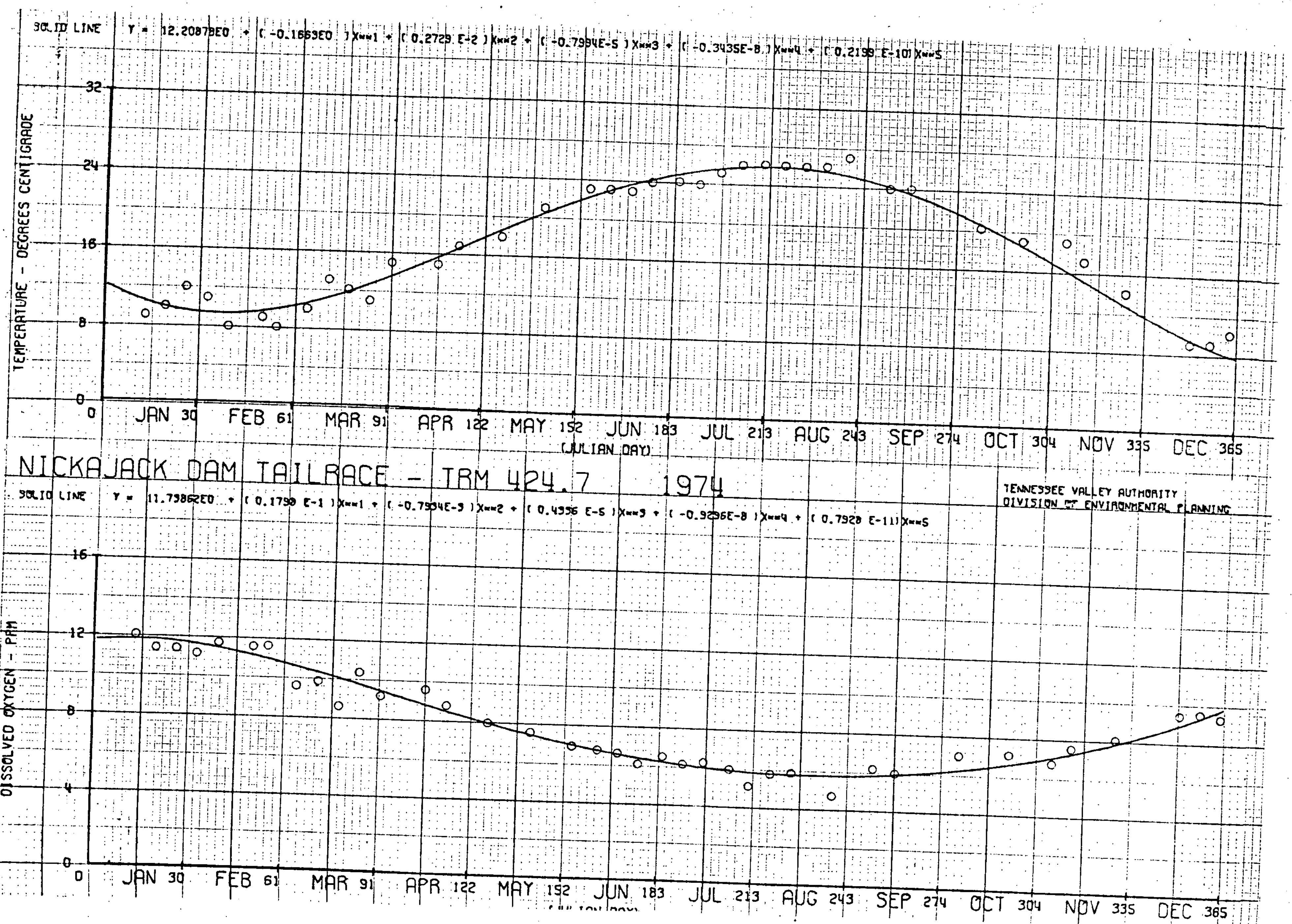


Figure 4.7 Temperature and Dissolved Oxygen Data for Releases from Nickajack Dam - 1974

POOR ORIGINAL

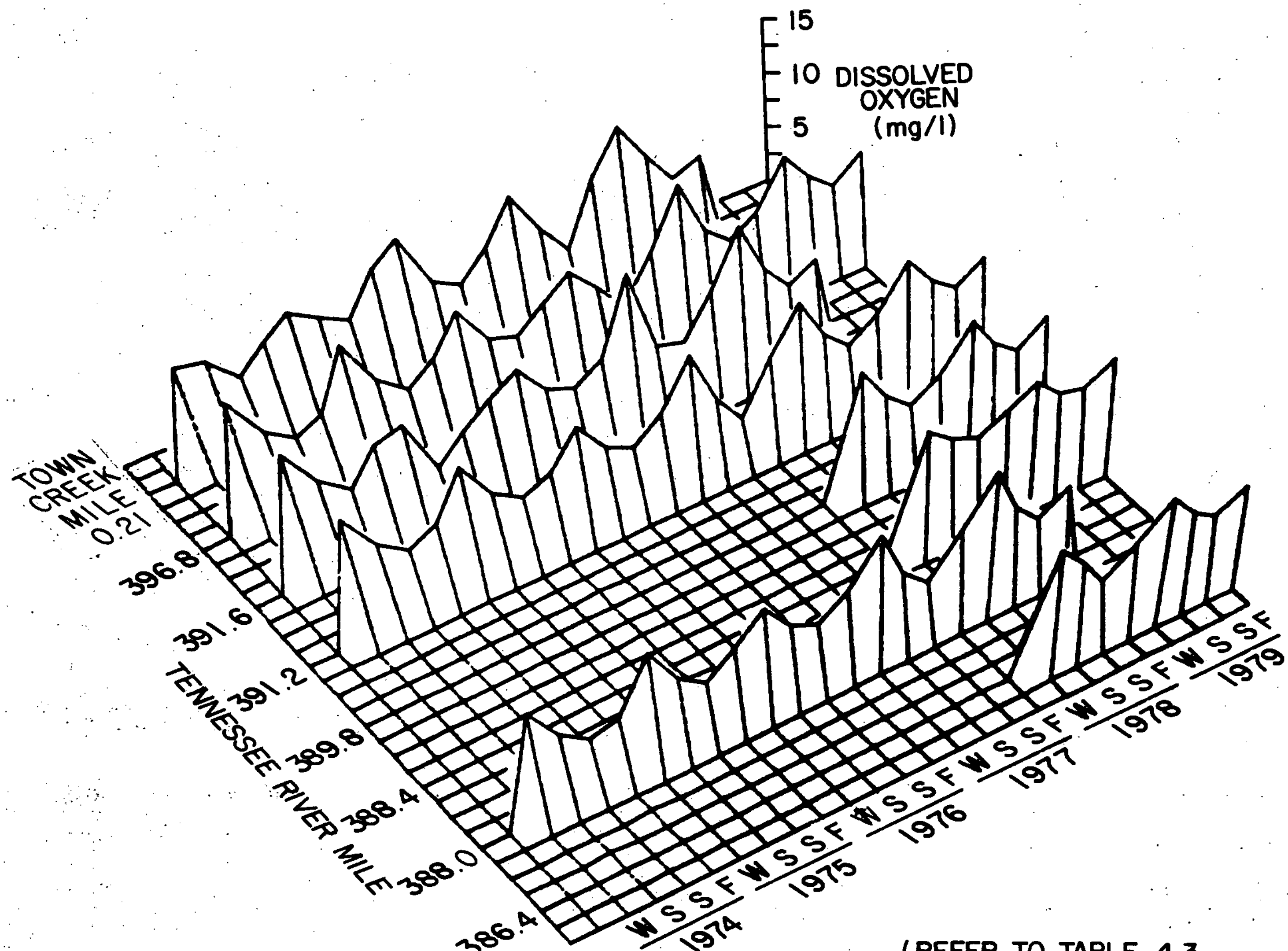
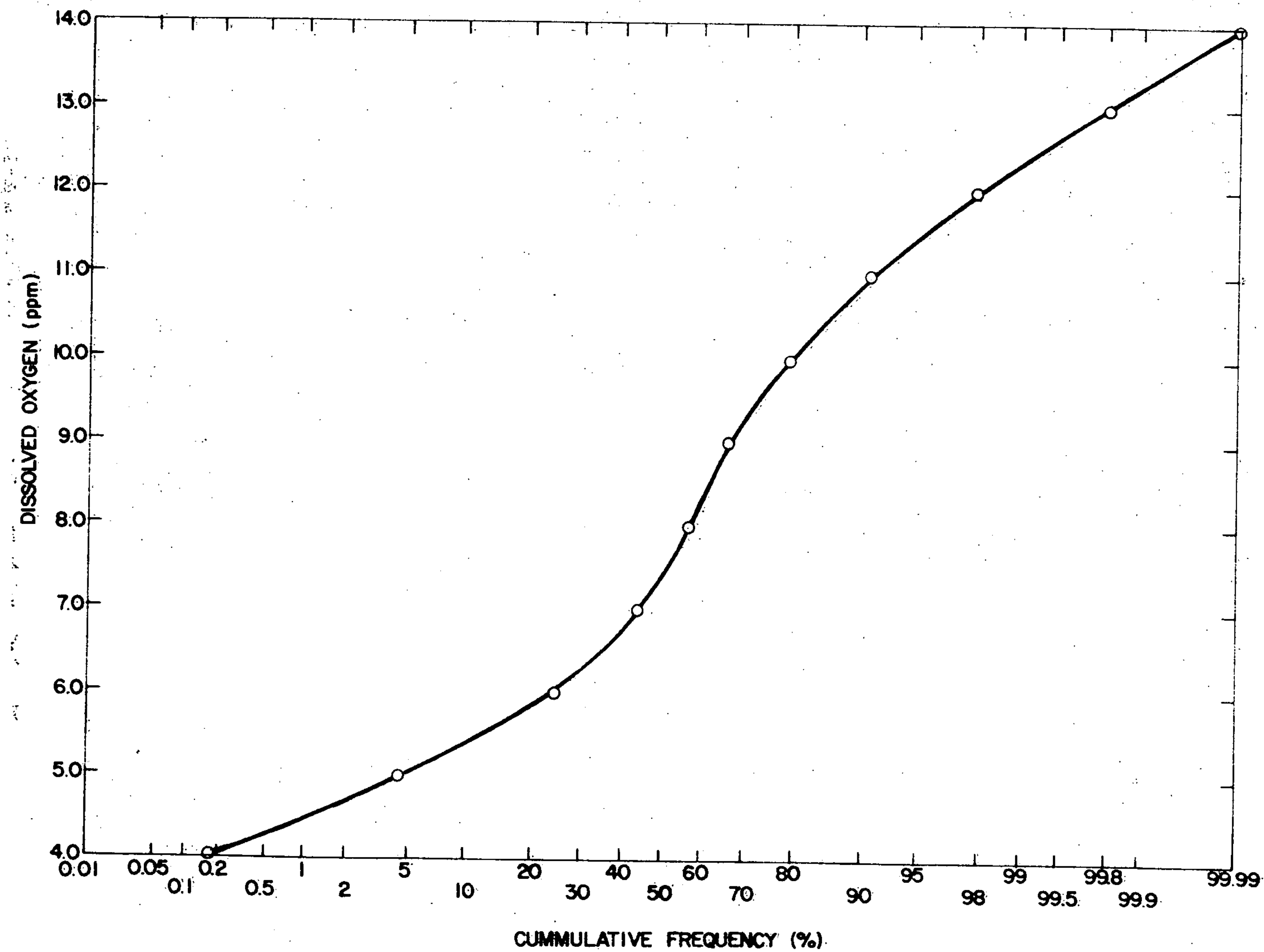


Figure 4.8 Quarterly Averaged Dissolved Oxygen Data in the Vicinity of the Bellefonte Nuclear Plant, 1974-1979

FIGURE 4.9

PERCENT OF WEEKLY DISSOLVED OXYGEN MEASUREMENTS
LESS THAN OR EQUAL TO INDICATED VALUE
NICKAJACK DAM TAILRACE (1969-1979)



5.0 SEDIMENT

Introduction

Surface runoff and construction activities are two primary causes of inorganic sediment deposits in streams. Particulates in suspension reduce light penetration and thus decrease photosynthesis. Sediments in the form of silt, sand, clay, or other insoluble materials cover the bottom of lakes and streams and may limit bottom dwelling organisms by reducing available food or suitable habitat. However, some burrowing species may be favored by sediment accumulation. Excessive inorganic sedimentation generally results in a reduction of all organisms, rather than being selective in its effect.

Methods and Materials

Two replicate samples for sediment analysis were collected each monthly survey with a Ponar grab sampler at TCM 0.2 and TRM's 388.0, 391.2, and 396.8. Samples were placed in plastic bags, placed on ice, and returned to the laboratory for organic and particle size composition determination. Particle size was determined in accordance with TVA Quality Assurance Procedure (TVA 1978).

The silt and clay fractions of the sediment were analyzed in more detail than the larger sediment fractions since they are the components most likely to enter the aquatic environment as a result of construction activities.

Sediment data were collected from 1974 to 1979; however, when the four left overbank stations were added to the monitoring program in 1978, sediment sampling was not continued at those sites after an initial sampling to characterize the substrates. Left overbank stations are isolated from construction activities and are expected to remain stable in substrate content.

Results and Discussion

The Tennessee River channel stations are characterized by gravel and sand substrates with small percentages of silt, clay, or organic materials, while the Town Creek station is composed mainly of sand, silt, and clay (table 5.1).

As shown in tables 5.2 and 5.3, the channel station at TRM 388.0 began to increase in percentages of silt and clay in 1978. These increases caused this station to become dissimilar from other channel stations. A large increase in silt occurred at this station in 1978 as composition increased from 2.6 percent in 1977 to 19.5 percent in 1978. Although the stations at TRM 391.2 and 396.8 showed a slight increase in clay and silt in 1978, no clay was observed in 1979. An analysis of correlation (p = o) was made to document significant changes of the clay and silt substrates over time (table 5.4). A highly significant relationship between percentage silt and time (r = 0.77433) was observed at TRM 388.0. The other channel stations showed no relationship between silt and time. A highly significant relationship between percentage clay and time (r = 0.73160) was also documented at TRM 388.0. No significant changes occurred at other stations. Changes occurring at TRM 388.0 were neither natural nor related to construction activities at BNP. A commercial dredging operation, Dixie Sand and Gravel Company, which operates out of Chattanooga, Tennessee, has been dredging in the vicinity of this station for several years under a permit issued by the U.S. Army Corps of Engineers.* This gravel operation dredged across the monitoring station at TRM 388.0 during the assessment period, thus altering the composition of the substrate. Plans for continued dredging in the vicinity of the BNP has potential for further altering both sediment and macrobenthic data from that presented in this evaluation. A detailed presentation of these analyses is presented in another report (TVA 1980b).

*Personal communication, February 6, 1980, Frank N. Harrison, President, Dixie Sand and Gravel Company, Chattanooga, Tennessee.

Literature Cited

Tennessee Valley Authority. 1978. Quality Assurance Procedure, WQEB-SS-2, Standard Methods for the Laboratory Analysis of Aquatic Biological Samples, Division of Environmental Planning.

Tennessee Valley Authority. 1980b. Bellefonte Nuclear Plant Construction Effects Monitoring Report, 1974-1979. Volume I, Division of Water Resources. 211 pp.

Table 5.1

PERCENTAGE COMPOSITION (MEAN) VALUES FOR THE SAND, GRAVEL, AND ORGANIC SUBSTRATE COMPONENTS OF THE CHANNEL STATIONS AND TOWN CREEK MILE 0.2 BELLEFONTE NUCLEAR PLANT 1974-1979

		Percentage composition (mean) values			
Year	Component	TCM 0.2	TRM 388.0	TRM 391.2	TRM 396.8
1974	sand	44.9	0.5	0.0	0.0
	gravel	2.7	94.5	100	100
	organic	2.72	0	0.0	0.0
1975	sand	44.6	0	0	0
	gravel	0.0	100	100	100
	organic	2.8	0	0	0
1976	sand	40.9	7.63	7.47	6.05
	gravel	0	91.91	92.17	93.67
	organic	4.63	0.0	0.0	0.0
1977	sand	30.27	14.57	3.65	0.43
	gravel	0	82.52	96.10	99.48
	organic	3.73	0	0	0
1978	sand	48.77	37.23	6.71	8.23
	gravel	0.38	15.91	92.58	88.93
	organic	5.09	4.32	0.24	0.49
1979	sand	38.36	45.35	0	0
	gravel	0.66	7.73	100	100
	organic	7.67	4.72	0	0

Table 5.2

RANKED PERCENTAGE COMPOSITION (MEAN) VALUES FOR THE CLAY AND SILT SUBSTRATE COMPONENTS AT THE CHANNEL STATIONS AND TOWN CREEK MILE 0.2 BELLEFONTE NUCLEAR PLANT 1974-1979

		Composition of substrate			
Year	Component	TCM 0.2	TRM 388.0	TRM 391.2	TRM 396.8
1974	clay	34.5	a	a	a
	silt	20.6	0.0	0.0	0.0
1975	clay	29.2	a	a	a
	silt	25.0	0.0	0.0	0.0
1976	clay	22.3	a	a	a
	silt	36.6	0.31	0.26	0.25
1977	clay	11.9	a	a	a
	silt	39.7	2.6	0.14	0.02
1978	clay	24.1	27.3	0.8	0.4
	silt	25.1	19.5	0.8	0.3
1979	clay	32.0	28.5	0.0	0.0
	silt	28.9	18.4	0.0	0.0

a. Samples not analyzed for the clay component.

Table 5.3

PERCENTAGE COMPOSITION (MEAN) VALUES FOR THE SILT SUBSTRATE COMPONENT
AT CHANNEL LOCATIONS AND TOWN CREEK MILE 0.2
BELLEFONTE NUCLEAR PLANT, 1974-1979

	TCM 0.2	TRM 388.0	TRM 391.2	TRM 396.8
1974				
Mean	20.6	0.0	0.0	0.0
	n = 45		n = 27	
1975				
Mean	25.0	0.0	0.0	0.0
	n = 76		n = 46	
1976				
Mean	36.0	0.31	0.26	0.25
	n = 89		n = 54	
1977				
Mean	39.7	2.6	0.14	0.02
	n = 85		n = 54	

Table 5.3 (continued)

1978

	TCM 0.2	TRM 388.0	TRM 391.2	TRM 396.8
Mean	25.1	19.5	0.8	0.3
	n = 76		n = 47	

1979

	TCM 0.2	TRM 388.0	TRM 391.2	TRM 396.8
Mean	28.9	18.4	0.6	0.0
	n = 86		n = 54	

Table 5.4

ANALYSIS OF CORRELATION (p=o) BETWEEN PERCENTAGE SILT AND CLAY AND TIME (1974-1979) FOR EACH CHANNEL STATION AND TOWN CREEK MILE 0.2 - BELLEFONTE NUCLEAR PLANT

Station	Correlation coefficient (r)	Degrees of freedom	Significance levels of r[a] 5%	1%
		Clay		
TRM 388.0	0.73160	51	0.271	0.351
TRM 391.2	0.14754	51	0.271	0.351
TRM 396.8	0.21809	51	0.271	0.351
TCM 0.2	0.10482	51	0.271	0.351
		Silt		
TRM 388.0	0.77433	51	0.271	0.351
TRM 391.2	0.12776	51	0.271	0.351
TRM 396.8	0.20522	51	0.271	0.351
TCM 0.2	0.17149	51	0.271	0.351

a. r values greater than the significance levels are significant.

6.0 PHYTOPLANKTON

Introduction

The phytoplankton community is made up of microscopic, free-floating unicellular and multicellular nonvascular plants suspended in the water column and composed of three major taxonomic divisions--Chrysophyta, mostly diatoms; Chlorophyta, green algae; and Cyanophyta, blue-green algae. Other divisions represented in phytoplankton include Euglenophyta, Pyrrhophyta, and Cryptophyta.

There can be considerable day-to-day variation in the growth of phytoplankton caused by factors such as temperature, nutrients, and availability of light. Considerable variations also exist between seasonal populations and communities of phytoplankton.

Materials and Methods

Preoperational phytoplankton studies were conducted at mainstream channel stations located at Tennessee River Mile (TRM) 388.0, 391.2, and 396.8, and one station in Town Creek at TCM 0.2. Phytoplankton communities were sampled to establish a baseline description of composition, seasonal community numbers, chlorophyll *a* concentrations, and carbon-14 estimates of primary productivity.

In March 1978 phytoplankton monitoring was expanded to include the left overbank of the river. Stations were selected at TRM 386.4, 388.4, and 391.1 for monitoring because it was felt that this area could be exposed to the thermal plume from BNP under low flow and reverse flow conditions.

Two replicate water samples for phytoplankton enumeration, chlorophyll analysis, and primary productivity estimates were collected with an 8-liter Van Dorn water sampler from the surface, 1 m, 3 m, and 5 m depths at each channel station, and from the surface and 1 m depth at TCM 0.2. Two replicate samples were collected for phytoplankton enumeration at the surface and 1 m depth at the left overbank locations. Water samples for phytoplankton enumeration were poured into 100-ml plastic bottles, and preserved with 2 ml of 37 percent formalin. In the laboratory each sample was agitated, a 15-ml aliquot was placed in a counting chamber, allowed to settle a minimum of 12 hours and enumerated. Generic enumerations were made with the aid of an inverted microscope (320X).

Chlorophyll samples were processed in the field by filtering 500 ml of water from each sample through cellulose ester filter pads in 1973 and 1974 and through glass fiber filter pads after 1974. From 1974-1977, each filter was folded and placed inside a paper absorbent pad and placed inside a light-excluding container with ice for subsequent laboratory analysis.

During 1978, the filters were folded and placed inside a paper absorbent pad, stored on dry ice in a light-excluding container, and shipped by bus to the laboratory.

In the laboratory, chlorophyll was extracted by steeping the filter in 90 percent acetone for 24 hours in the dark at 4°C. When glass fiber filters were used the samples were filtered again through glass fiber filters immediately preceding spectrophotometric analysis. If cellulose ester filters were used, the samples were centrifuged before analysis.

Processed samples were transferred to a cuvette and the optical densities read at 750, 663, 645, and 630 nanometers (nm). The optical density (OD) readings at 663, 645, and 630 nm were first corrected for turbidity using the 750 nm reading. By using the equations of Richards and Thompson (1952), as modified by Parsons and Strickland (1963), these corrected OD readings were converted to determine chlorophyll a, b, and c. Standing crop of chlorophyll a was calculated in milligrams per cubic meter (mg Chl a/m^3). Values were then calculated for total pigment that occurred in a column of water 1 m^2 in cross sectional area and extending from the surface to a depth of 5 m and expressed as mg Chl a/m^2.

Samples for phytoplankton productivity were poured into Pyrex (125-ml) bottles. The bottles were stored in a light-excluding box until time for incubation.

Two microcuries (2 μc) of sodium bicarbonate radioisotope were added to each bottle. The bottles were then attached to a metered nylon line, suspended at the respective sample depths, and incubated for approximately three hours. At the surface and 5 m depth, a dark bottle was also attached to compensate for nonphotosynthetic assimilation of carbon-14.

After incubation, 1 ml of 10 percent formalin was added to each bottle to retard additional carbon incorporation. Samples were then filtered through 0.45-μ membrane filters and glued to stainless steel planchets and returned to the laboratory, where the activity of the filters was counted in a thin-window, low-background, gas-flow proportional counter.

Using the conversion table of Bachmann (1962), the total inorganic carbon available at each station was determined by utilizing pH readings, temperatures, and alkalinity values. The mean carbon-14 activity incorporated into the algal cells in the light bottles minus that absorbed by materials in the dark bottles resulted in the net autotrophic activity. Total carbon assimilated by the algal cells provided an estimate expressed in milligrams carbon per cubic meter per hour (mg $C/m^3/h$). These values, averaged for depth intervals, multiplied by the respective depth interval and summed, were used to represent total productivity that occurred in a column of water with a surface area of one square meter and a depth of 5 m.

Solar radiation through the water column was measured with a submarine photometer when primary productivity studies were conducted. The photometer consisted of an underwater sea cell and a matching deck cell for alternate surface and underwater illumination monitoring. Solar radiation was measured from sunrise to sunset by a recording portable pyroheliometer located in the vicinity of the incubation site.

Phytoplankton community structure was analyzed by computing diversity ($\bar{d}$) and Sorensen's Quotient of Similarity (Qs). Sorensen's Quotient of Similarity was determined by combining all taxa in samples from all sampling depths at each station. The formulae for these analyses are as listed:

(1) Diversity index ($\bar{d}$) values were calculated using the following equation (Patten, 1962):

$$\bar{d} = -\Sigma_1^s (n_1/n) \log_2 (n_1 n)$$

s = number of species in unit area

n_1 = number of individuals belonging to the i^{th} species

n = total number of organisms

$\bar{d}$ = diversity per individual

Results and Discussion

Temporal and spatial distributions of phytoplankton taxa that were commonly collected at channel stations and TCM 0.2 are presented in appendix B. The number of genera collected ranged from a low of 13 at TRM 391.2 in September 1974, to a high of 61 at TCM 0.2 in July 1976, (tables 6.1 and 6.2, figures 6.1 to 6.7). Numbers were usually highest during the summer months and lowest during fall and winter months. A similar pattern was evident from phytoplankton data at the left overbank stations. The greatest number of genera observed (1978-1979) was 62 at TRM 391.1 in July 1978, and the lowest was 14 at TRM 386.4 in October 1978. In 1979, the channel station at TRM 396.8 was sampled in conjunction with the overbank stations and the number of genera ranged from 40 in July to 18 in October. In addition to genera listed in appendix B, there were 26 genera that were collected infrequently--less than three times during the year (table 6.3). The greatest number of genera collected were Chlorophyta followed by Chrysophyta, Cyanophyta, Euglenophyta, Pyrrhophyta, and Cryptophyta (figures 6.8 to 6.14).

During 32 of 44 sampling periods, the density of phytoplankton was higher at TCM 0.2 than at either of the three channel stations as shown in table C.1 of appendix C and graphically displayed in figures 6.15 to 6.19. At TCM 0.2 densities ranged from 40,546 x 10^3/liter in August 1978 to 91 x 10^3/liter in September 1975. Phytoplankton densities at the channel stations ranged from 14,367 x 10^3/liter at TRM 391.2 in August 1978 to 60 x 10^3liter at TRM 396.8 in August 1977. In 1978 and 1979, densities from the left overbank stations ranged from 13,150 x 10^3/liter at TRM 391.1 in July 1978, to 1461 x 10^3/liter at TRM 386.4 in October 1979 (figures 6.20 and 6.21, and table C.2 in appendix C). The channel station at TRM 396.8 in 1979, ranged from 3207 x 10^3/liter in February to 123 x 10^3/liter in October (table C.2).

Phytoplankton standing crop numbers are shown by divisions in tables C.3 through C.9 of appendix C, with respective percentage composition shown in appendix D. The Chrysophyta usually dominated the community from February through May and the Cyanophyta showed significant increases from June through October. However, in 1974, Chrysophyta dominated throughout except at TCM 0.2 where Chlorophyta dominated in June and July.

The dominance of Cyanophyta (blue-green algae) over the total assemblage from June through October 1975 and 1976 was addressed in the Operational License Stage Environmental Report (OLER) (TVA, 1978). This trend was observed at channel (figures 6.22-6.25) and overbank (figures 6.26-6.28) stations and continued throughout the remainder of the preoperational period (1977-1979). It is assumed that physical factors such as reservoir flow and temperature were highly related to the dominance of Cyanophyta (this assumption is supported in OLER). It should be emphasized that Cyanophyta dominated at stations upstream and downstream from the projected impact zone of the thermal plume from BNP. Upstream versus downstream comparisons are illustrated in figures 6.29-6.33 for channel locations and figures 6.34-6.35 for overbank stations. Cyanophyta dominance demonstrated during the preoperational phase of monitoring is expected to continue into the operational stage for years of similar flows and water temperatures.

Diversity index evaluates an entire community based on observations that natural communities generally have large numbers of species with few individuals per species. A value is determined for this relationship between species and numbers of individuals and this nondimensional value is then assigned to the community. A community with only one species would have an index of zero, while a community with more species, each being equally numerous, would have an index greater than zero. The more species and the less dominant any single species becomes, the higher the index.

During the six year study period, $\bar{d}$ indices were always above 1.0 except in April 1976, when $\bar{d}$ values were <1 at all stations (appendix E). Values for the rest of the period varied from 1^+ to 3^+ for channel stations, and 1^+ to 3^+ for channel stations, and 1^+ to 4^+ for the station at TCM 0.2.

Sorensen's Quotient of Similarity (table 6.4) indicated that the channel stations were more similar to each other in the spring than during the rest of the year. On the overbank there was greater similarity among the stations in spring and summer than in winter or fall (table 6.5). No attempt was made to statistically compare channel stations with those on the overbank because of habitat and hydrological differences.

Monthly chlorophyll a pigment concentrations are shown in appendix F. Because of an error in sample handling, 1977 data were invalidated. For the rest of the sampling period concentrations ranged from 39.32 mg of Chl a/m^2 at TRM 396.8 in July 1978, to 0.32 mg/m^2 at TRM 388.0 in September 1975 (table 6.6).

Water depths varied seasonally at TCM 0.2, limiting vertical sampling to a maximum depth of one meter; hence, depth integration values were not determined. The highest single chlorophyll value observed at the channel stations was 13.35 mg Chl a/m^3 at a depth of 3 m in July 1976. No chlorophyll was observed at the surface for TRM 388.0 and TRM 391.2 in September 1975, and at TRM 396.8 in October 1975, which probably resulted from a laboratory error. As expected, single values observed at TCM 0.2 were generally higher than those in the mainstream of the river, ranging from 37.92 mg Chl $\underline{a}/m^3$ at 1 m in August 1978 to 0.04 mg Chl $\underline{a}/m^3$ in March 1976.

There was no apparent pattern for seasonal comparison of observed chlorophyll values. For example, highest values in 1974 were obtained in June at the channel stations, while in 1976, lowest values were obtained in June at the same stations. As another example, concentrations in October 1978, were higher at all three stations than they were at any time in 1974. Generally the monthly observed values were similar at each of the channel stations.

Primary productivity estimates are shown in appendix G. Chemical, temperature, solar radiation, and Secchi visibility data are summarized in table 6.7. Results of primary productivity estimates were not consistent at the mainstream stations. High and low values varied greatly for the same season from one year to the next. However, at TCM 0.2, minimum values were usually observed in the fall or early spring while maximum values were observed in the summer.

Literature Cited

Bachmann, R. W. 1962. "Evaluation of a Modified C^{14} Technique for Shipboard Estimation of Photosynthesis in Large Lakes." Great Lakes Res. Publ. No. 8:61.

McCain, J. C., 1975. "Fouling Community Changes Induced by the Thermal Discharge of a Hawaiian Power Plant," Environ. Pollut. 9:63-83.

Parsons, T. R. and J. D. H. Strickland. 1963. "Discussion of Spectrophotometer Determination of Marine-Plant Pigments, with Revised Equations for Ascertaining Chlorophylls and Carotenoids." J. Mar. Res. 21:158-163.

Patten B. C. 1962. "Species Diversity in Net Phytoplankton of Raritan Bay." J. Mar. Res. 20:57-75.

Richards, F. A. and T. G. Thompson. 1952. "The Estimation and Characterization of Plankton Populations by Pigment Analysis. II. A Spectrophotometric Method for the Estimation of Plankton Pigments." J. Mar. Res. 11:156-172.

Table 6.1

NUMBER OF PHYTOPLANKTON GENERA COLLECTED AT TCM 0.2 AND CHANNEL STATIONS EACH SAMPLING PERIOD - BELLEFONTE NUCLEAR PLANT GUNTERSVILLE RESERVOIR - 1974-1978

Month	Station	Number of genera				
		1974	1975	1976	1977	1978
February	TRM 388.0	16	22	43	33	a
	TRM 391.2	13	18	42	35	a
	TRM 396.8	19	22	40	34	a
	TCM 0.2	26	24	37	34	a
March	TRM 388.0	19	20	39	28	26
	TRM 391.2	21	19	43	25	31
	TRM 396.8	18	17	41	28	30
	TCM 0.2	27	26	35	32	28
April	TRM 388.0	22	23	37	20	21
	TRM 391.2	25	25	34	19	26
	TRM 396.8	24	23	33	23	23
	TCM 0.2	28	35	28	39	33
May	TRM 388.0	15	41	32	31	31
	TRM 391.2	17	42	44	31	40
	TRM 396.8	15	38	36	28	32
	TCM 0.2	29	59	41	50	48
June	TRM 388.0	32	39	46	43	42
	TRM 391.2	34	33	37	31	43
	TRM 396.8	26	43	32	26	41
	TCM 0.2	46	50	33	38	44
July	TRM 338.0	26	36	50	42	46
	TRM 391.2	33	35	48	49	46
	TRM 396.8	25	27	46	45	45
	TCM 0.2	41	55	61	44	57
August	TRM 388.0	32	37	38	20	35
	TRM 391.2	32	45	39	15	42
	TRM 396.8	23	39	36	17	28
	TCM 0.2	31	45	39	41	50
September	TRM 388.0	21	26	23	33	32
	TRM 391.2	13	21	33	37	25
	TRM 396.8	14	17	21	37	27
	TCM 0.2	17	17	42	40	36
October	TRM 388.0	16	23	21	28	17
	TRM 391.2	18	23	19	27	19
	TRM 396.8	19	22	19	22	15
	TCM 0.2	18	47	14	31	15

a. Samples not collected.

Table 6.2

NUMBER OF PHYTOPLANKTON GENERA COLLECTED AT LEFT OVERBANK STATIONS EACH SAMPLING PERIOD
BELLEFONTE NUCLEAR PLANT - GUNTERSVILLE RESERVOIR
1978-1979

		Phytoplankton X 10^3/liter								
Year	Station	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1978	TRM 386.4	a	31	35	48	42	60	41	36	14
	TRM 388.4	a	24	36	33	44	60	44	48	18
	TRM 391.1	a	36	37	41	35	62	51	63	31
1979	TRM 386.4	23	16	44	45	31	50	19	36	23
	TRM 388.4	23	15	38	26	26	51	29	47	23
	TRM 391.1	29	25	40	38	27	48	37	52	20
	TRM 396.8[b]	32	28	31	28	33	40	24	35	18

a. No samples collected.

b. Channel station.

Table 6.3

INFREQUENTLY COLLECTED PHYTOPLANKTON GENERA FROM VICINITY OF BELLEFONTE NUCLEAR PLANT - GUNTERSVILLE RESERVOIR 1974-1979

Chrysophyta
- *Hrysarachnion*
- *Mallomonas*
- *Ophiocytium*
- *Stauroneis*
- *Synura*

Chlorophyta
- *Bracteacoccus*
- *Closterium*
- *Echinosphaerella*
- *Gloeocystis*
- *Microspora*
- *Oedogonium*
- *Planktospaeria*
- *Pseudotetraedron*
- *Pryamimonas*
- *Selenastrum*
- *Sphaerocystis*
- *Spondylosium*
- *Stigeoclonium*
- *Volvox*

Cyanophyta
- *Anabaenopsis*
- *Occochloris*
- *Raphidiopsis*

Euglenophyta
- *Cryptoglena*
- *Phacus*

Pyrrhophyta
- *Ceratium*
- *Peridinium*

Total Taxa - 26

Table 6.4

SEASONAL COMPARISON OF MAINSTREAM PHYTOPLANKTON COMMUNITIES
SORENSEN'S QUOTIENT OF SIMILARITY
IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT 1974-1978

Stations compared			1974	1975	1976	1977	1978[a]
					Winter		
TRM 388.0	to	TRM 391.2	75.9	75.0	79.5	76.5	
	to	TRM 396.8	80.0	68.2	79.0	74.6	
	to	TCM 0.2	61.9	70.9	76.9	77.6	
TRM 391.2	to	TRM 396.8	75.0	70.0	85.4	84.0	
	to	TCM 0.2	61.5	57.1	78.5	84.0	
TRM 396.8	to	TCM 0.2	66.7	56.5	85.7	82.4	
					Spring		
TRM 388.0	to	TRM 391.2	85.9	79.7	76.3	84.8	78.2
	to	TRM 396.8	86.6	80.8	77.2	78.5	77.5
	to	TCM 0.2	70.3	67.7	77.3	71.2	73.9
TRM 391.2	to	TRM 396.8	85.4	76.5	77.3	78.0	81.0
	to	TCM 0.2	75.8	71.9	73.0	69.8	79.7
TRM 396.8	to	TCM 0.2	72.3	65.6	75.9	69.0	77.3
					Summer		
TRM 388.0	to	TRM 391.2	74.9	84.5	70.7	81.2	82.8
	to	TRM 396.2	72.9	78.9	73.9	72.7	74.7
	to	TCM 0.2	75.4	74.2	73.0	75.2	77.8
TRM 391.2	to	TRM 396.8	72.6	79.1	81.0	72.6	78.4
	to	TCM 0.2	70.4	72.7	72.4	72.4	77.7
TRM 396.8	to	TCM 0.2	71.9	77.2	77.2	69.9	73.4
					Fall		
TRM 388.0	to	TRM 391.2	72.9	72.4	59.9	75.8	72.9
	to	TRM 396.8	74.2	68.7	79.0	82.0	73.7
	to	TCM 0.2	77.1	67.3	65.4	77.1	71.6
TRM 391.2	to	TRM 396.2	71.7	73.4	67.8	77.1	65.0
	to	TCM 0.2	71.6	68.9	71.8	77.1	69.7
TRM 396.8	to	TCM 0.2	67.8	66.8	60.3	79.2	68.2

a. Samples were not collected.

Table 6.5

SEASONAL COMPARISON OF OVERBANK PHYTOPLANKTON COMMUNITIES
SORENSEN'S QUOTIENT OF SIMILARITY
IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT 1978-1979

Stations compared			Sorensen's Quotient 1978[a]	1979
			Winter	
TRM 386.4	to	TRM 388.4		45.5
	to	TRM 391.1		60.0
TRM 388.4	to	TRM 391.1		73.0
			Spring	
TRM 386.4	to	TRM 388.4	79.3	78.5
	to	TRM 391.1	82.9	78.8
TRM 388.4	to	TRM 391.1	78.4	76.1
			Summer	
TRM 386.4	to	TRM 388.4	78.6	77.7
	to	TRM 391.1	82.0	71.3
TRM 388.4	to	TRM 391.1	79.0	76.4
			Fall	
TRM 386.4	to	TRM 388.4	75.7	67.0
	to	TRM 391.1	62.6	63.7
TRM 388.4	to	TRM 391.1	74.2	73.2

a. Samples were not collected.

Table 6.6

SUMMARY OF CHLOROPHYLL a VALUES IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT 1974-1978

		Total Mg of Chl a/m^2			
Month	Year	TRM 388.0	TRM 391.2	TRM 396.8	TCM 0.2
February	1974	9.03	6.83	7.79	a
	1975	19.89	13.42	10.48	5.23
	1976	28.92	31.04	25.57	6.55
	1978	a	a	a	a
March	1974	7.82	3.55	4.40	-
	1975	6.11	6.89	8.52	5.13
	1976	28.35	5.33	4.70	0.39
	1978	6.42	20.10	17.41	1.00
April	1974	3.86	3.33	4.53	10.10
	1975	9.96	10.53	12.25	5.07
	1976	26.88	29.29	21.65	4.24
	1978	a	a	a	a
May	1974	10.93	11.43	9.92	4.79
	1975	7.03	6.90	7.98	4.30
	1976	11.94	14.71	12.83	3.25
	1978	12.29	11.56	14.78	12.83
June	1974	19.14	15.19	17.37	13.20
	1975	6.30	6.23	6.27	2.22
	1976	1.10	0.82	0.35	0.56
	1978	a	a	a	a
July	1974	4.34	4.71	35.16	0.80
	1975	5.78	4.98	5.24	4.52
	1976	11.48	13.52	4.23	6.66
	1978	23.29	22.70	39.32	6.94
August	1974	4.50	5.12	15.58	1.57
	1975	8.08	7.90	6.79	2.21
	1976	13.19	11.77	15.01	4.71
	1978	24.97	32.81	31.92	37.56
September	1974	4.05	6.15	6.72	1.98
	1975	0.32	0.94	1.85	0.84
	1976	13.97	10.52	7.93	5.02
	1978	18.12	22.24	16.92	4.39
October	1974	11.28	15.17	14.41	2.23
	1975	0.56	0.48	0.34	2.54
	1976	8.54	12.74	9.23	2.20
	1978	20.87	23.53	21.57	4.02

a. Samples not collected.

Table 6.7

SOLAR RADIATION, LIGHT PENETRATION, WATER TEMPERATURE, pH, AND TOTAL ALKALINITY FOR PHYTOPLANKTON PRODUCTIVITY, BELLEFONTE NUCLEAR PLANT - FEBRUARY-OCTOBER 1974-1978

Year	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
				Solar Radiation (langleys/day)					
1974	309	84	375	528	552	396	465	167	397
1975	151	446	476	458	533	388	409	41	334
1976	191	351	350	396	354	469	421	381	92
1977	355	528	365	554	408	172	320	213	148
1978[a]	-	519	109	274	349	344	234	228	180
				Secchi Disk Visibility Depth (meters)					
1974	0.5	0.95	0.75	1.5	1.25	1.6	1.8	1.6	2.0
1975	0.6	0.4	1.0	1.25	1.5	1.6	2.2	1.5	1.2
1976	1.0	1.3	1.7	0.9	1.2	1.6	1.6	2.0	2.0
1977	0.95	0.3	0.75	1.5	1.5	1.5	0.75	1.25	1.0
1978[a]	-	0.75	2.0	1.0	1.0	1.5	1.75	2.0	2.0
				Water Temperature at 1.0 m (°C)					
1974	10.7	10.2	14.0	18.3	22.2	23.9	26.1	25.0	21.0
1975	9.1	10.9	14.2	23.6	24.9	26.8	28.2	22.9	17.4
1976	6.8	13.2	19.6	19.1	23.7	26.6	26.4	24.4	18.1
1977	4.3	12.9	17.0	21.5	26.2	29.5	25.0	25.7	13.9
1978[a]	-	10.2	16.7	17.1	22.7	27.9	25.2	27.0	20.0
				pH					
1974	7.0	7.1	6.8	6.6	7.3	6.5	7.2	6.2	6.8
1975	7.3	6.4	7.5	7.1	7.1	7.2	7.2	7.3	7.2
1976	7.7	7.5	7.6	7.0	7.0	7.0	7.1	7.2	7.4
1977	7.8	7.4	7.0	7.4	7.3	7.2	7.2	7.2	7.3
1978[a]	-	7.5	7.5	7.3	7.6	6.4	7.4	7.2	7.2
				Total Alkalinity (mg $CaCO_3$/l)					
1974	50	46	47	55	50	49	53	47	47
1975	51	40	52	52	51	61	59	52	43
1976	50	60	51	40	50	42	49	50	56
1977	61	50	41	54	53	52	53	51	50
1978[a]	-	54	55	54	48	54	57	53	59

a. Biological samples were not collected in February 1978.

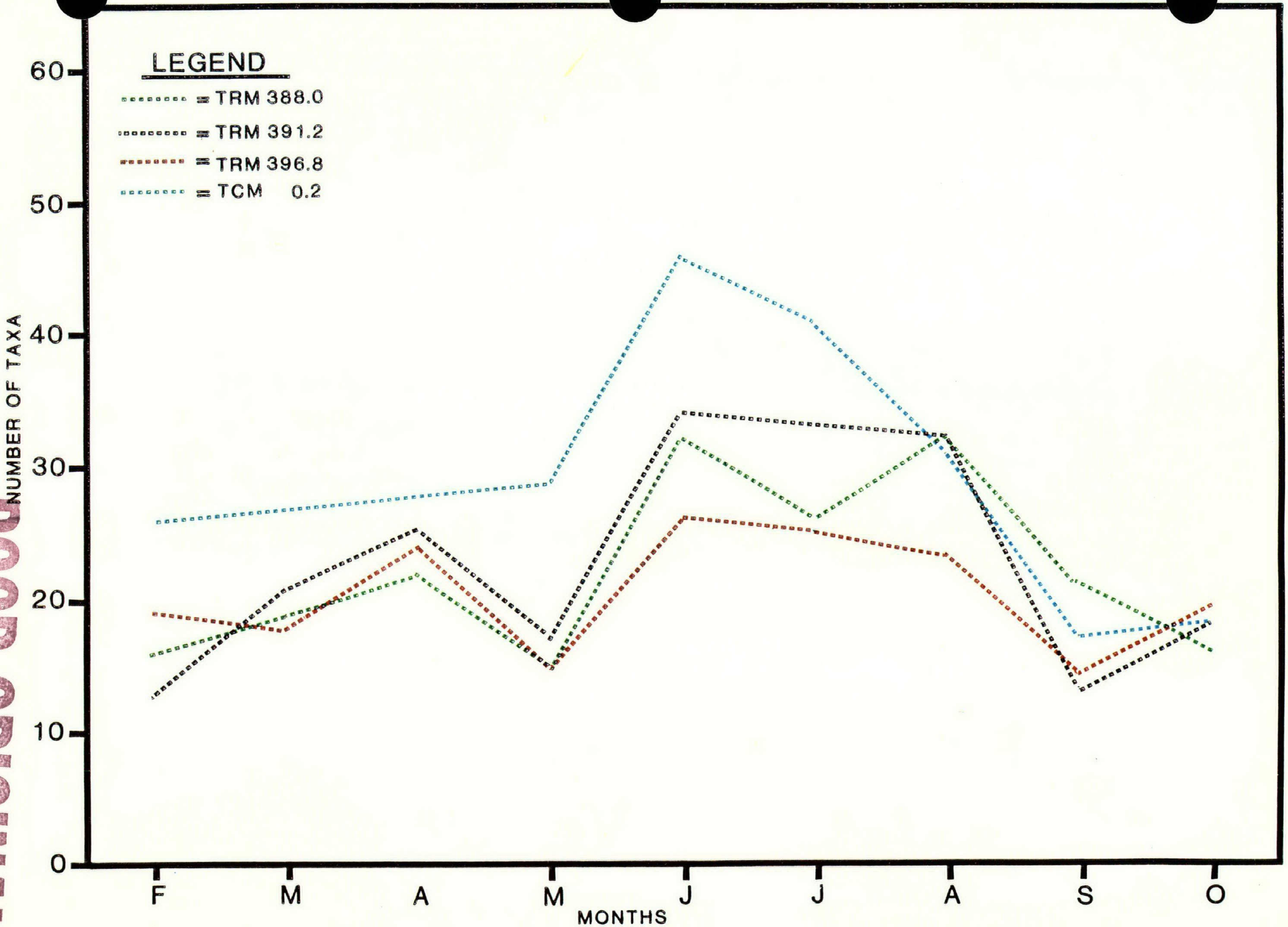


FIGURE - 6.1

NUMBER OF PHYTOPLANKTON TAXA COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1974

POOR ORIGINAL

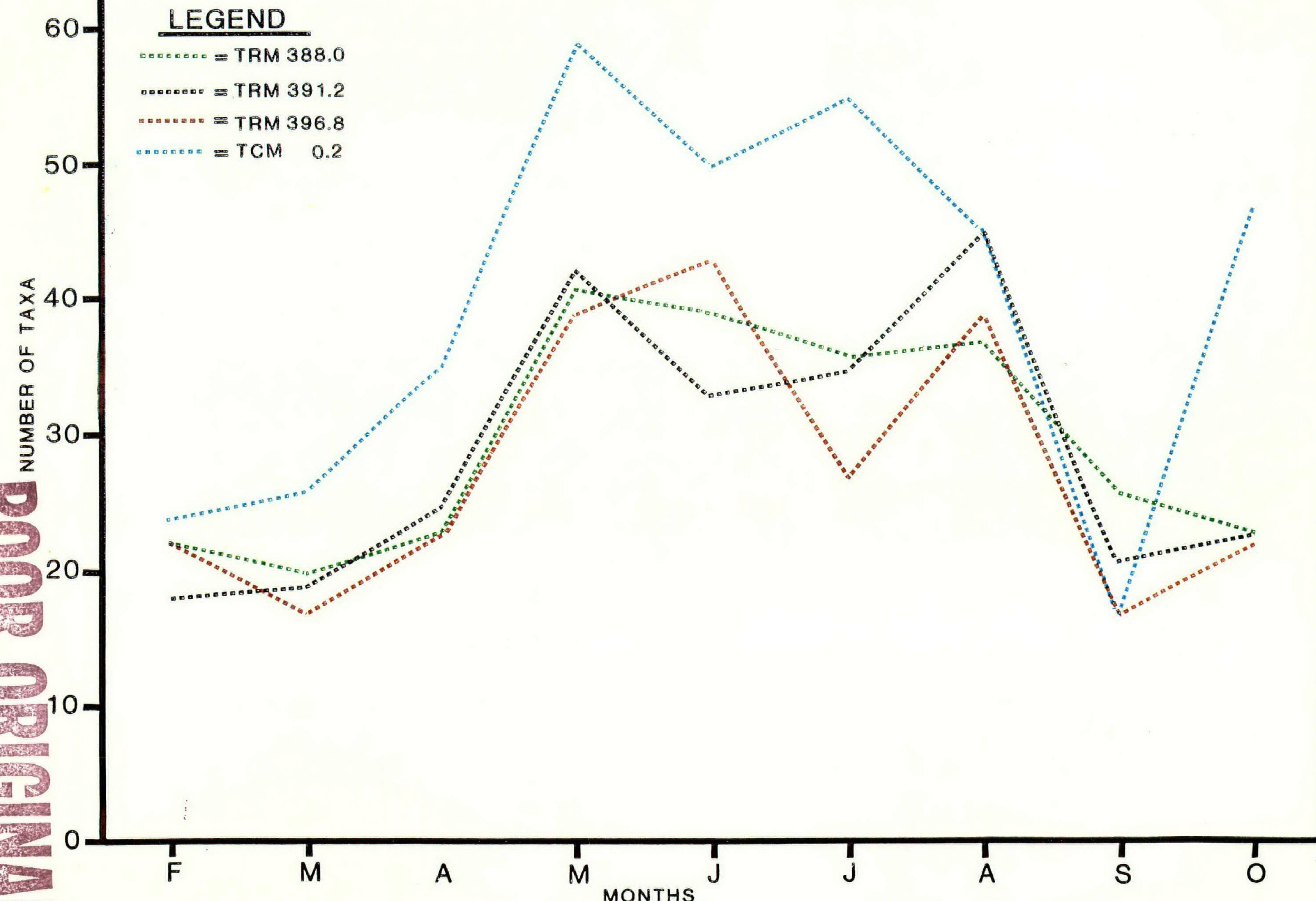


FIGURE - 6.2

NUMBER OF PHYTOPLANKTON TAXA COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1975

POOR ORIGINAL

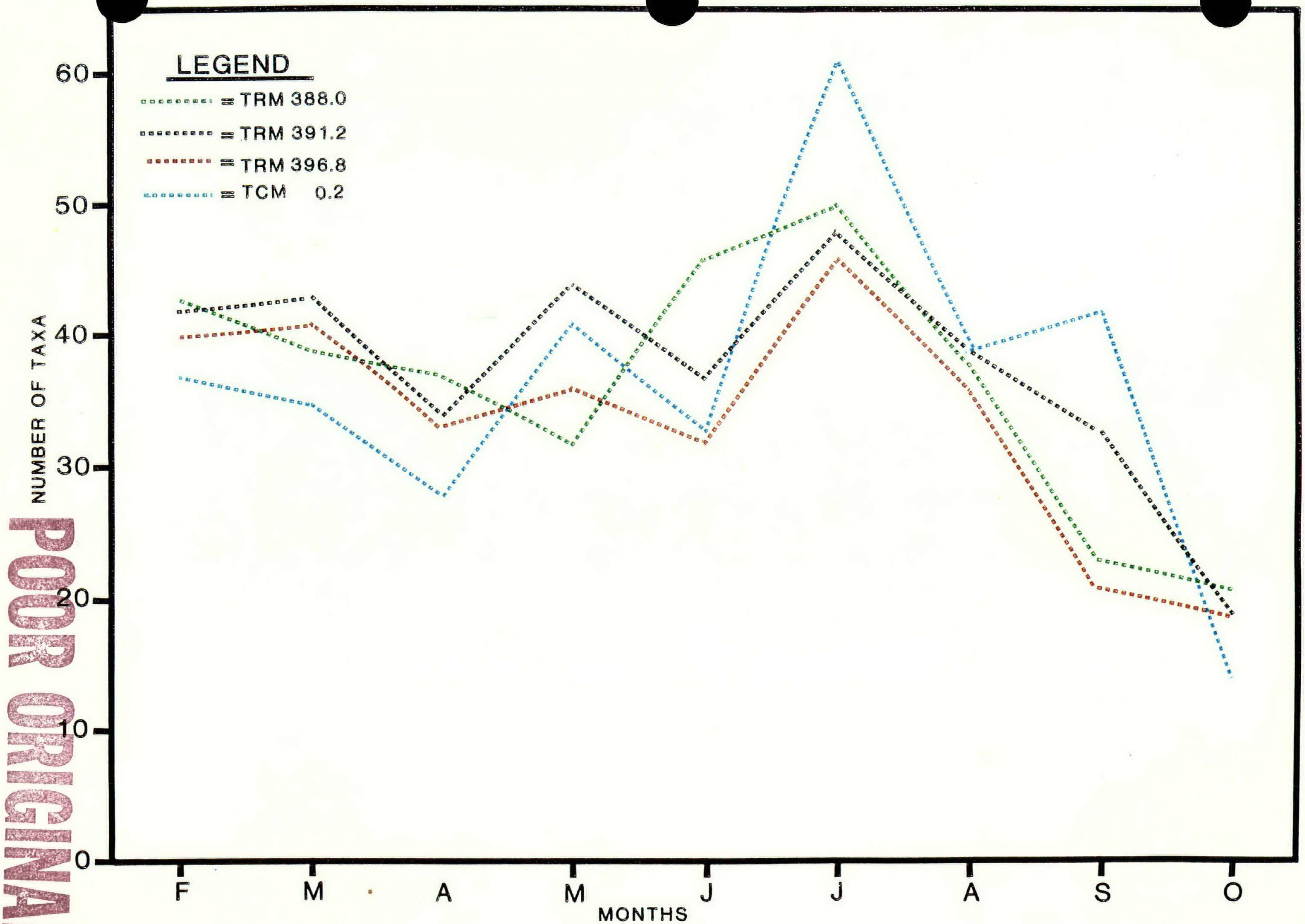


FIGURE - 6.3

NUMBER OF PHYTOPLANKTON TAXA COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1976

POOR ORIGINAL

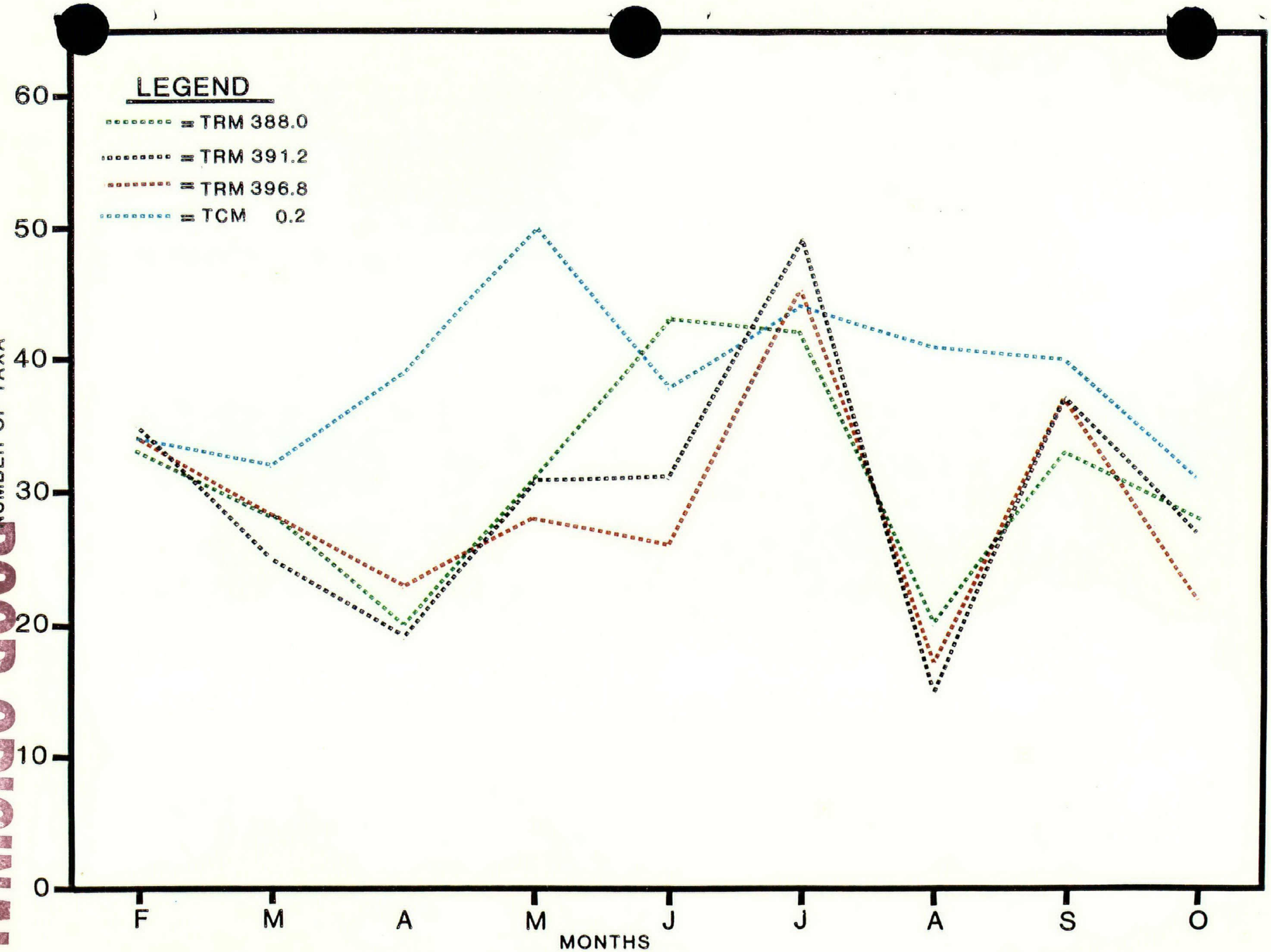


FIGURE - 6.4

NUMBER OF PHYTOPLANKTON TAXA COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1977

POOR ORIGINAL

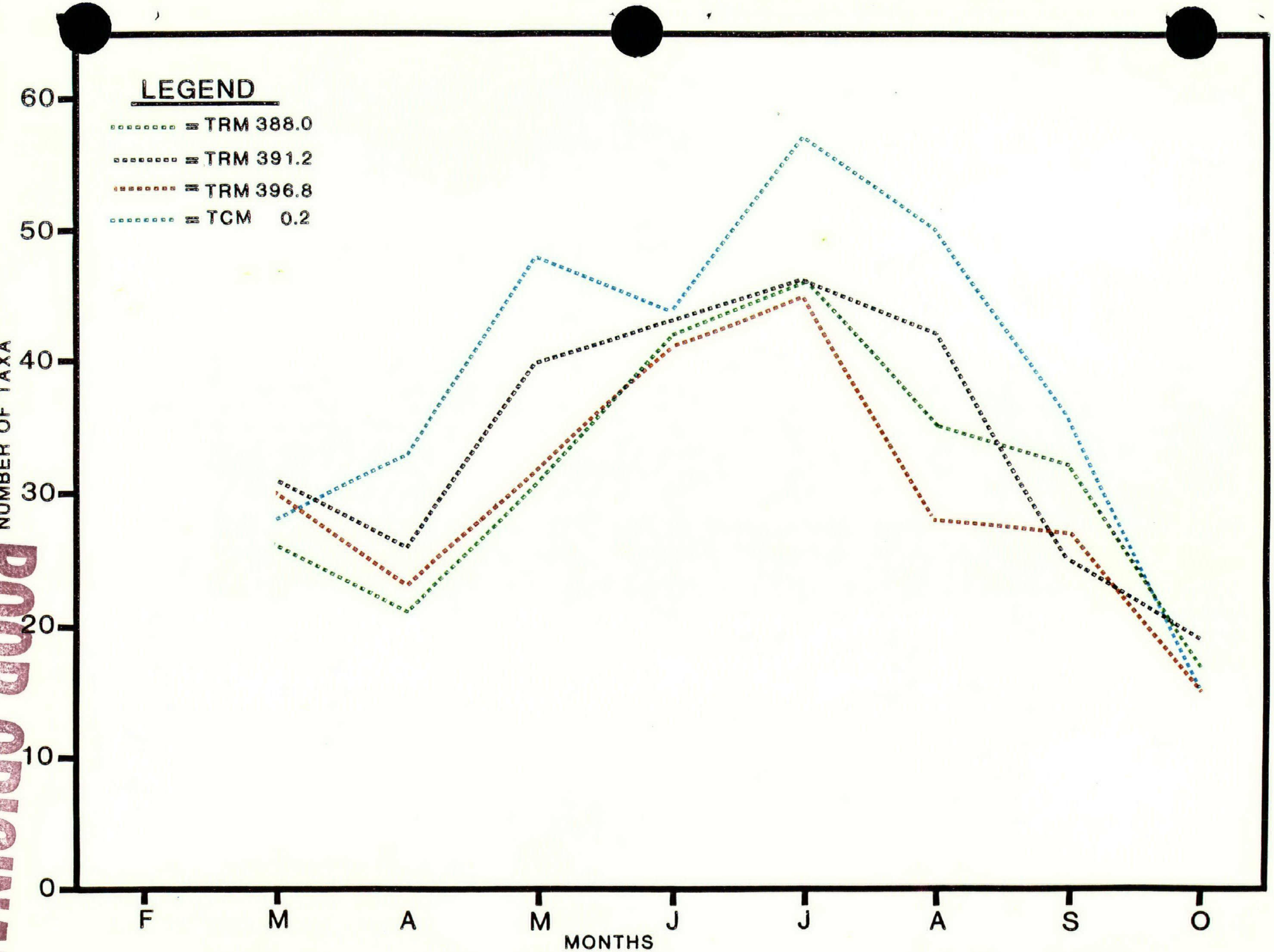


FIGURE - 6.5

NUMBER OF PHYTOPLANKTON TAXA COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - CHANNEL 1978

POOR ORIGINAL

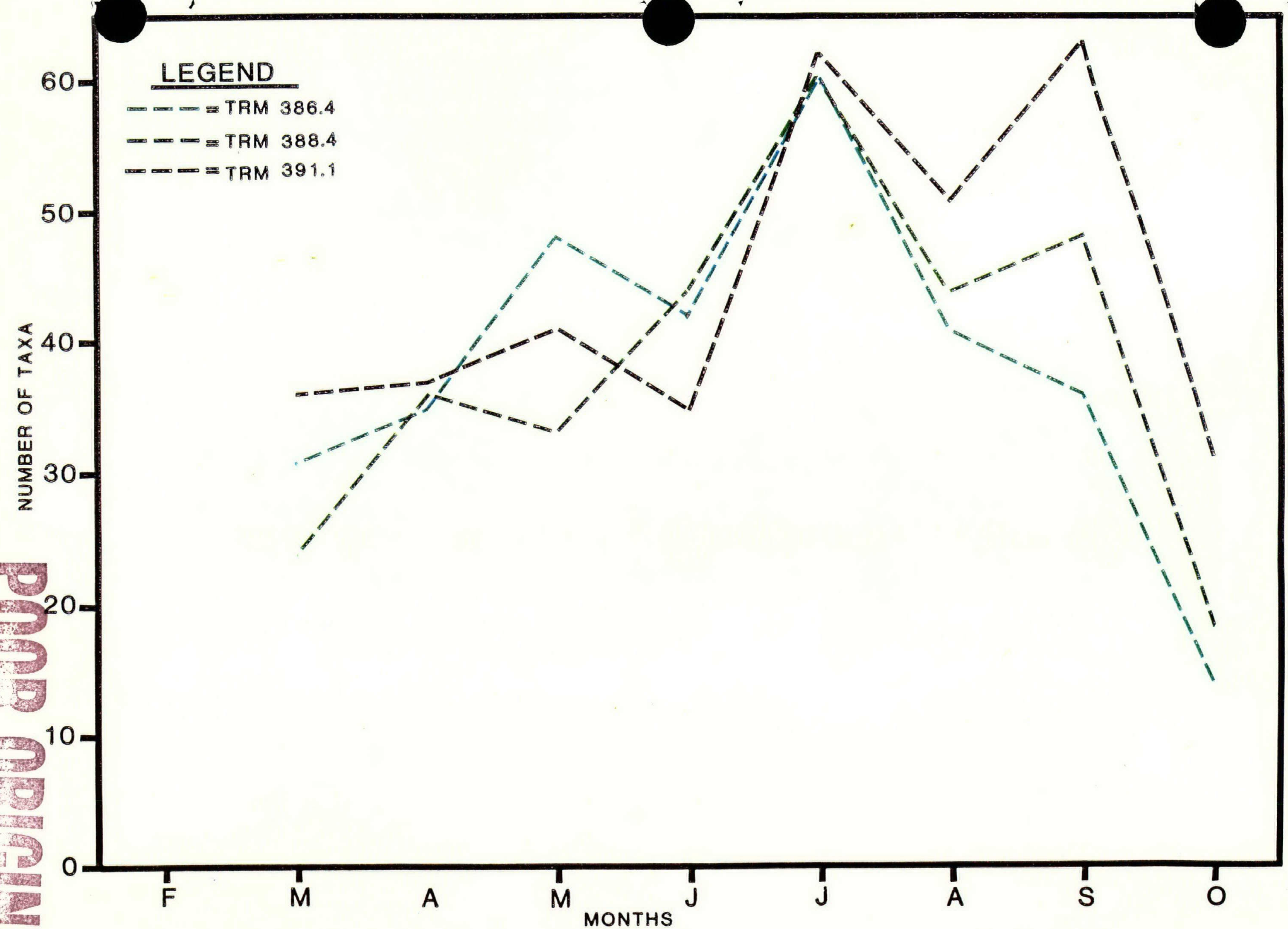


FIGURE - 6.6

NUMBER OF PHYTOPLANKTON TAXA COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - OVERBANK 1978

POOR ORIGINAL

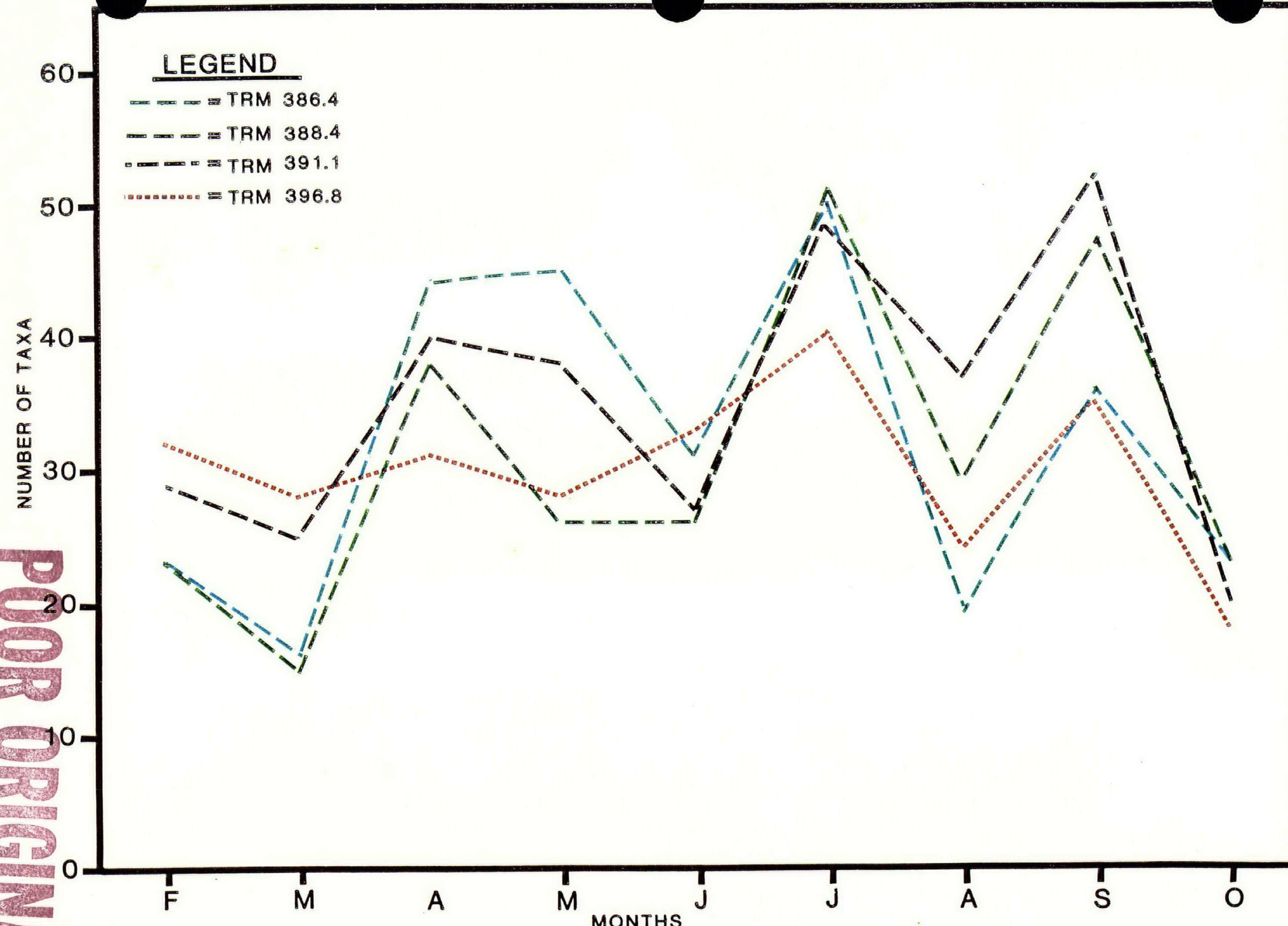


FIGURE - 6.7

NUMBER OF PHYTOPLANKTON TAXA COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1979

POOR ORIGINAL

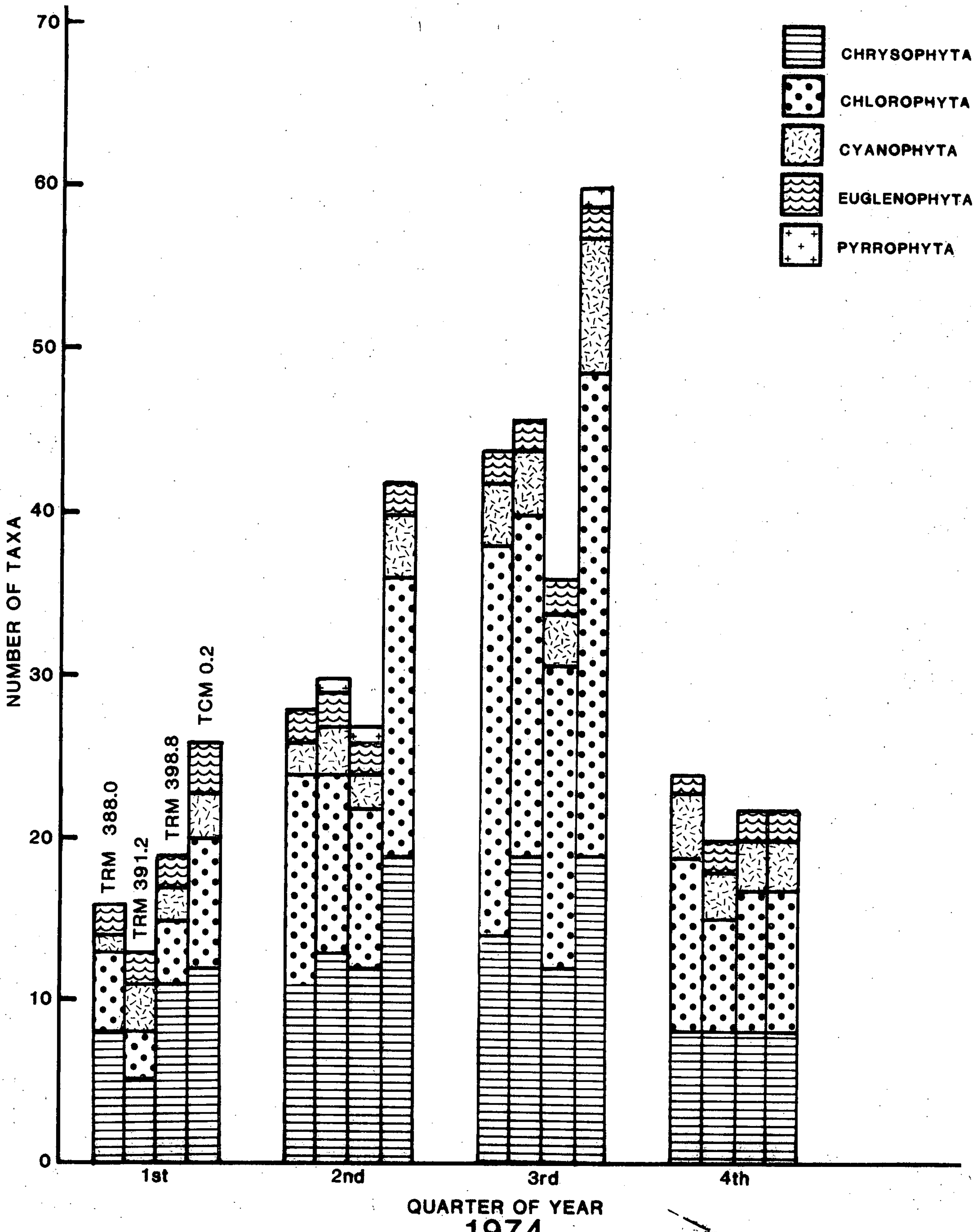


FIGURE 6.8

NUMBER OF TAXA IN EACH MAJOR PHYTOPLANKTON GROUP BY SEASON AND STATION COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

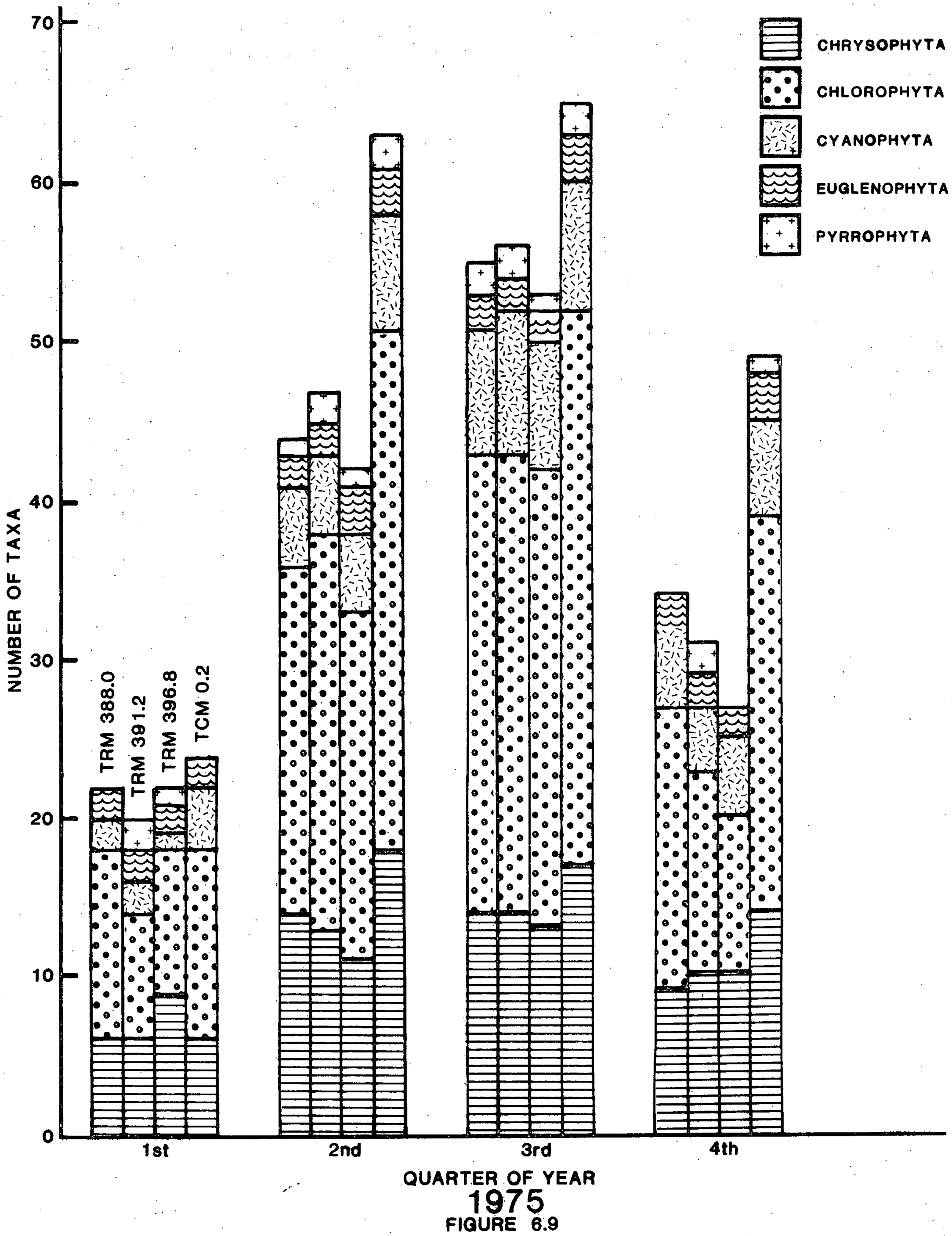


FIGURE 6.9

NUMBER OF TAXA IN EACH MAJOR PHYTOPLANKTON GROUP BY SEASON AND STATION COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

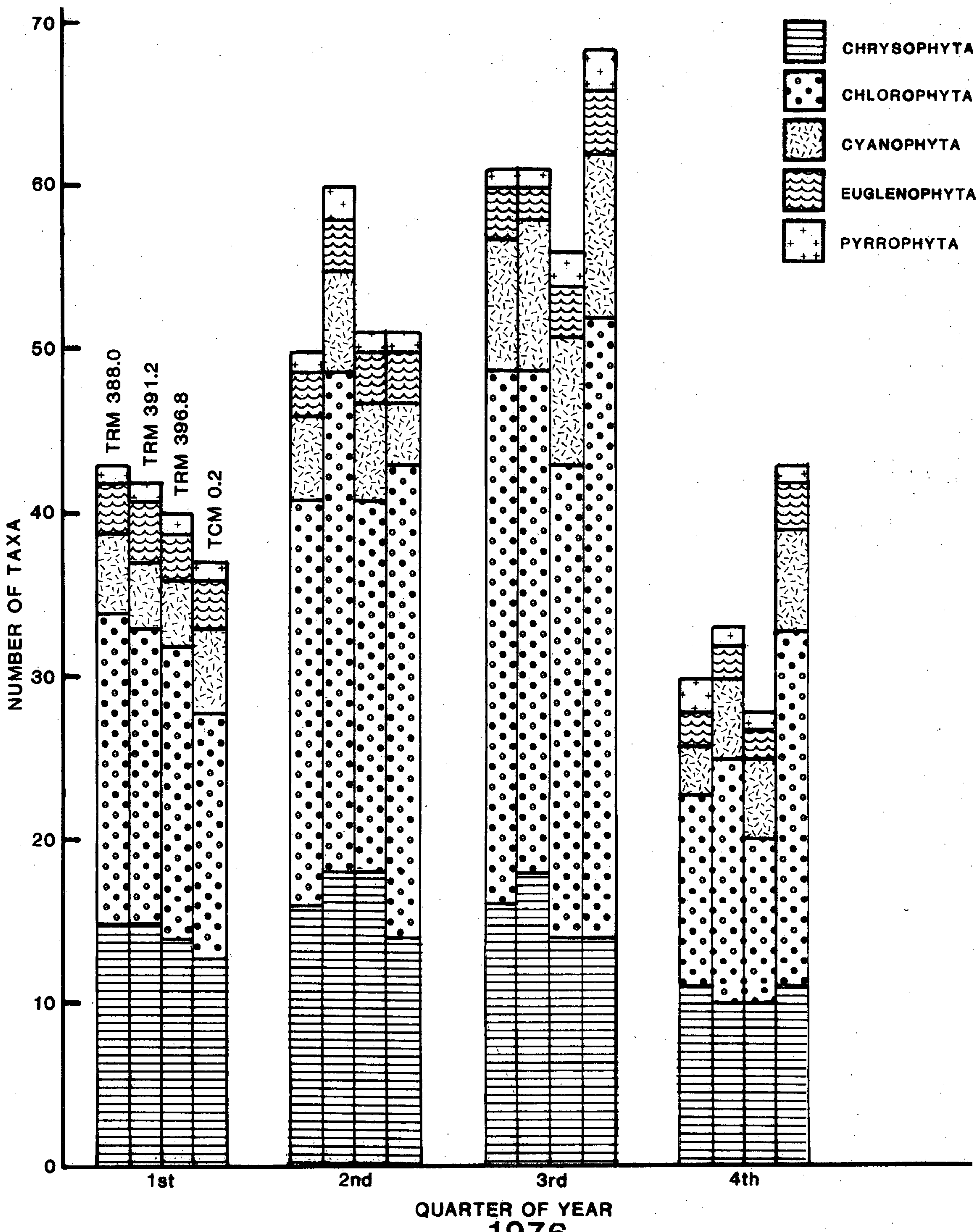


FIGURE 6.10

NUMBER OF TAXA IN EACH MAJOR PHYTOPLANKTON GROUP BY SEASON AND STATION COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

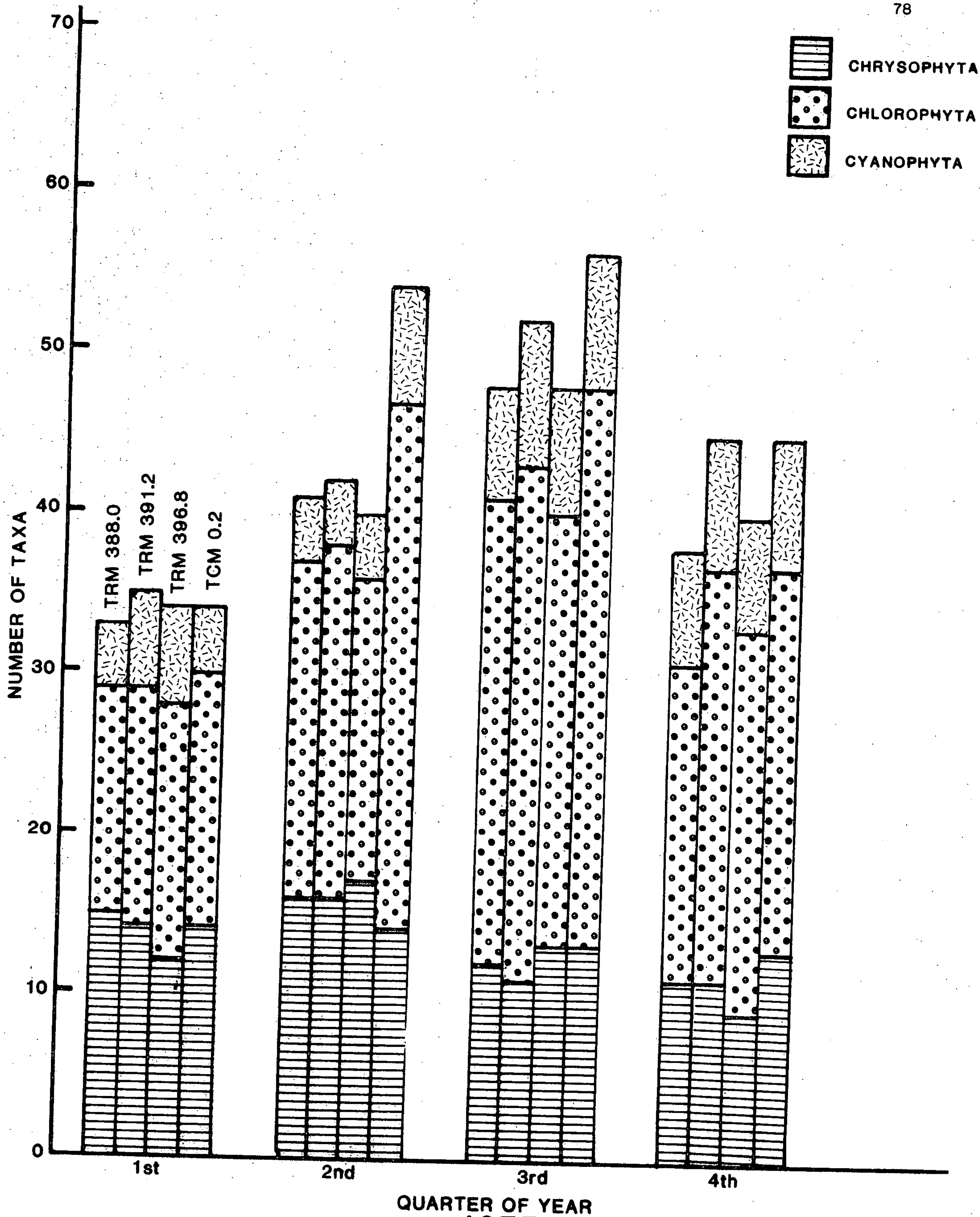


FIGURE 6.11

NUMBER OF TAXA IN EACH MAJOR PHYTOPLANKTON GROUP BY SEASON AND STATION COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

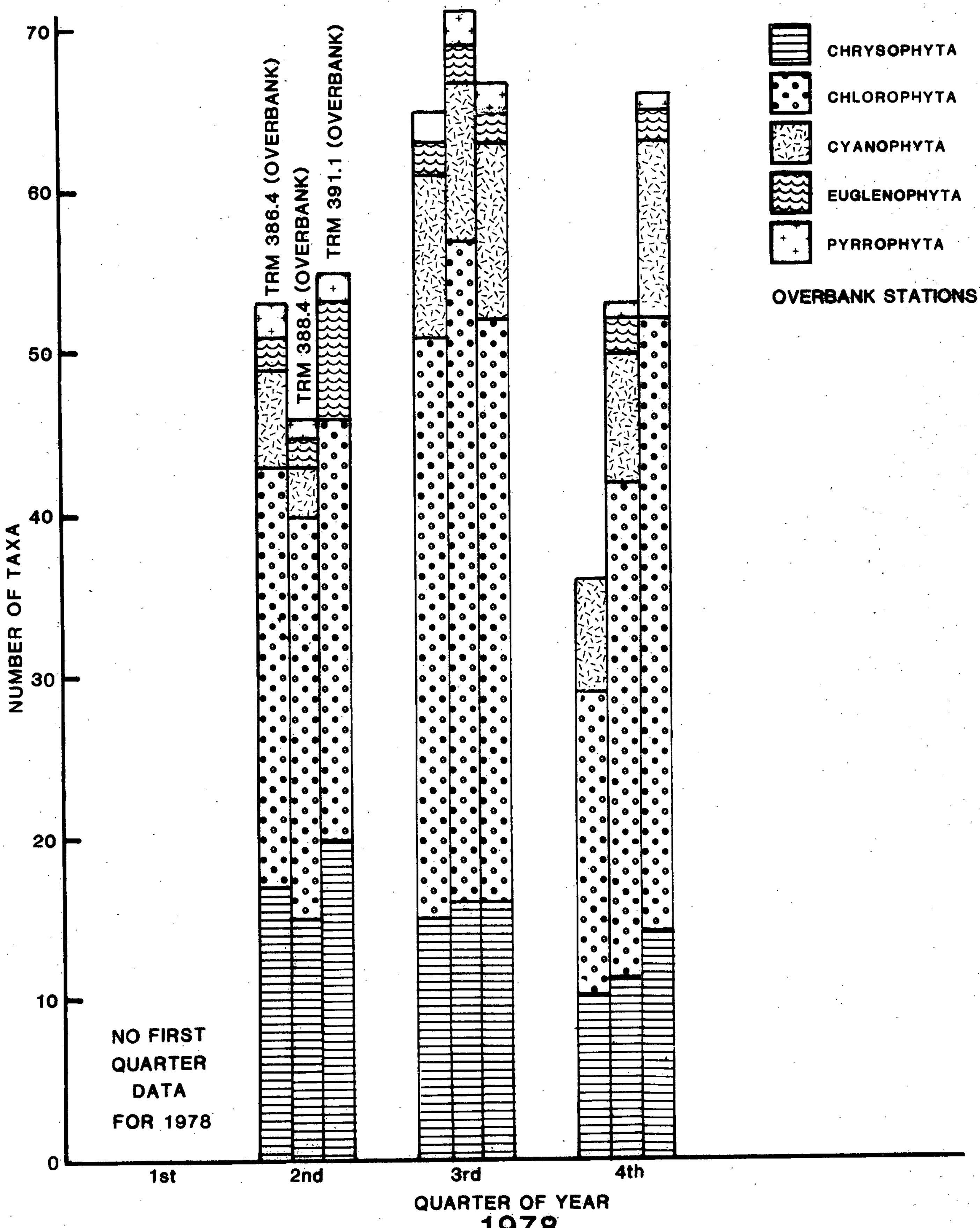


FIGURE 6.12

NUMBER OF TAXA IN EACH MAJOR PHYTOPLANKTON GROUP BY SEASON AND STATION COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

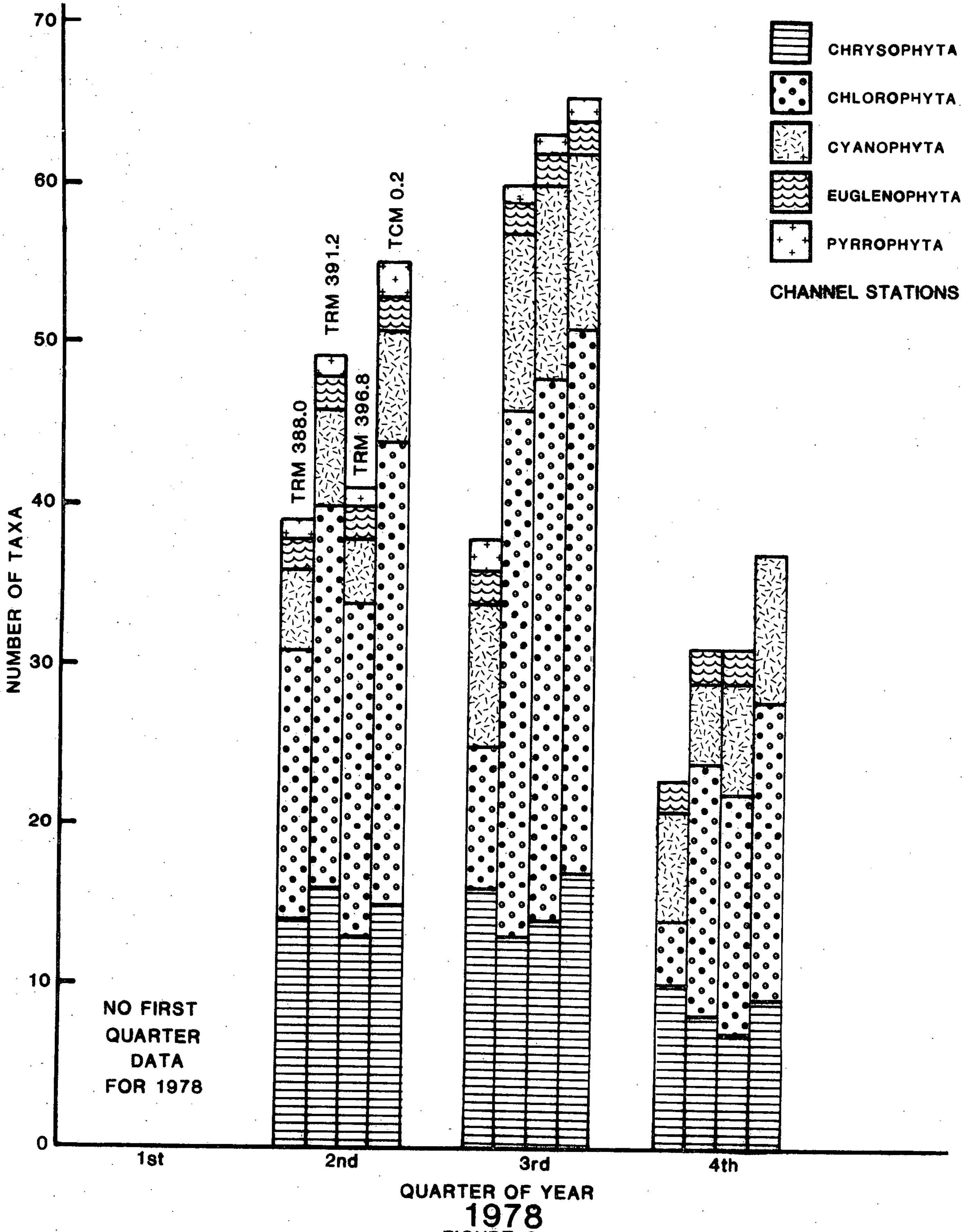


FIGURE 6.13

NUMBER OF TAXA IN EACH MAJOR PHYTOPLANKTON GROUP BY SEASON AND STATION COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

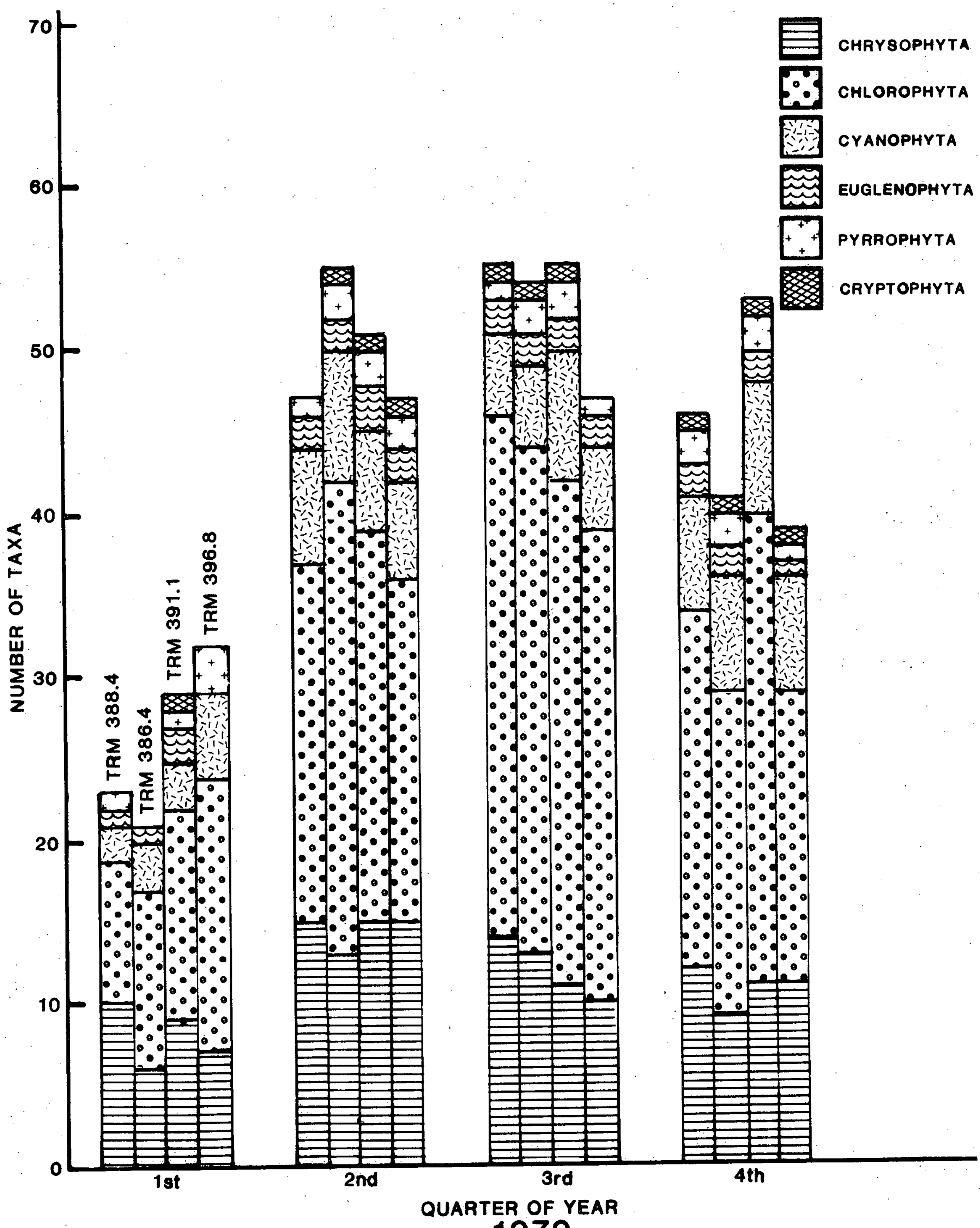


FIGURE 6.14

NUMBER OF TAXA IN EACH MAJOR PHYTOPLANKTON GROUP BY SEASON AND STATION COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

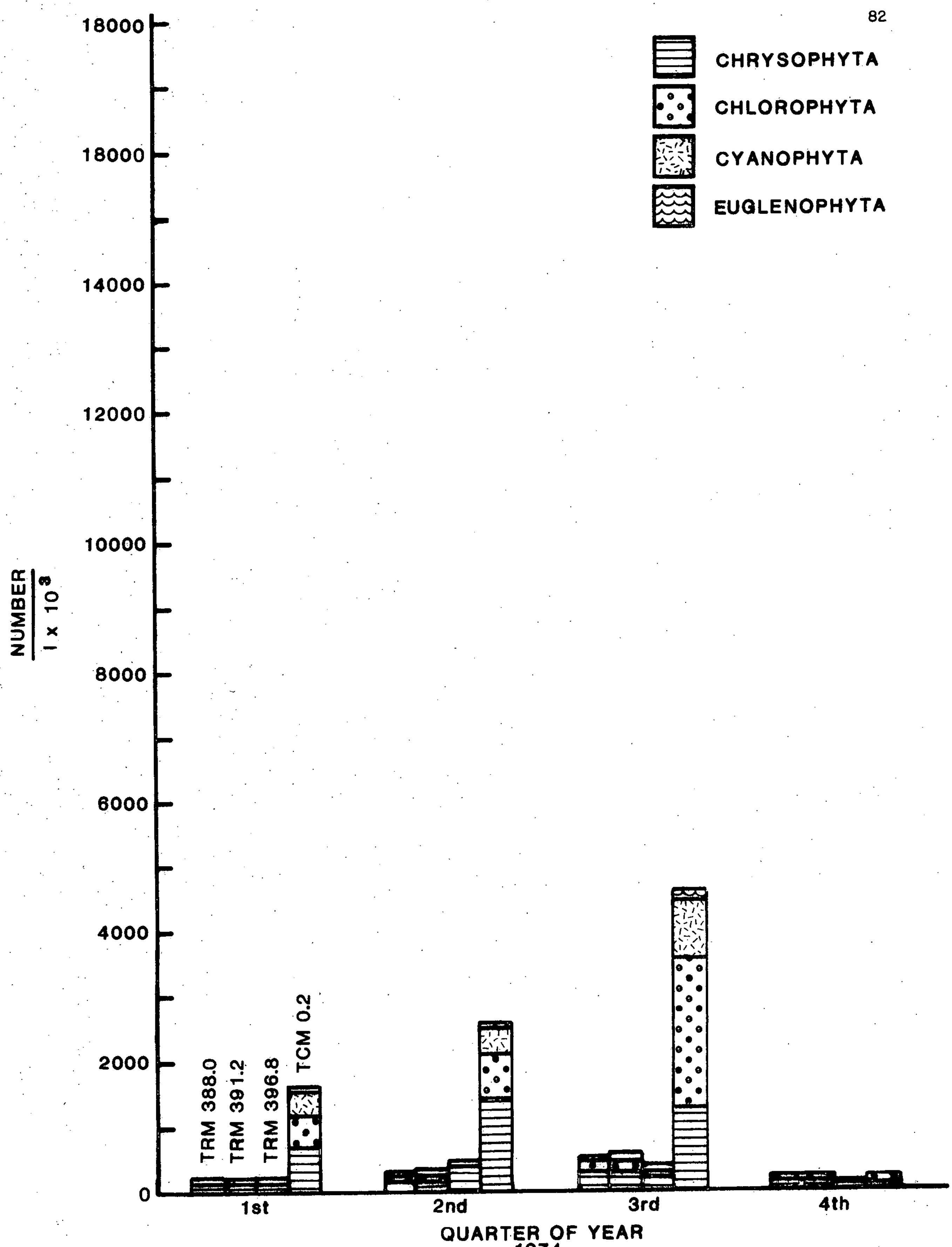


FIGURE 6.15

AVERAGE SEASONAL DENSITY OF THE PHYTOPLANKTON BY TAXONOMIC DIVISION IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

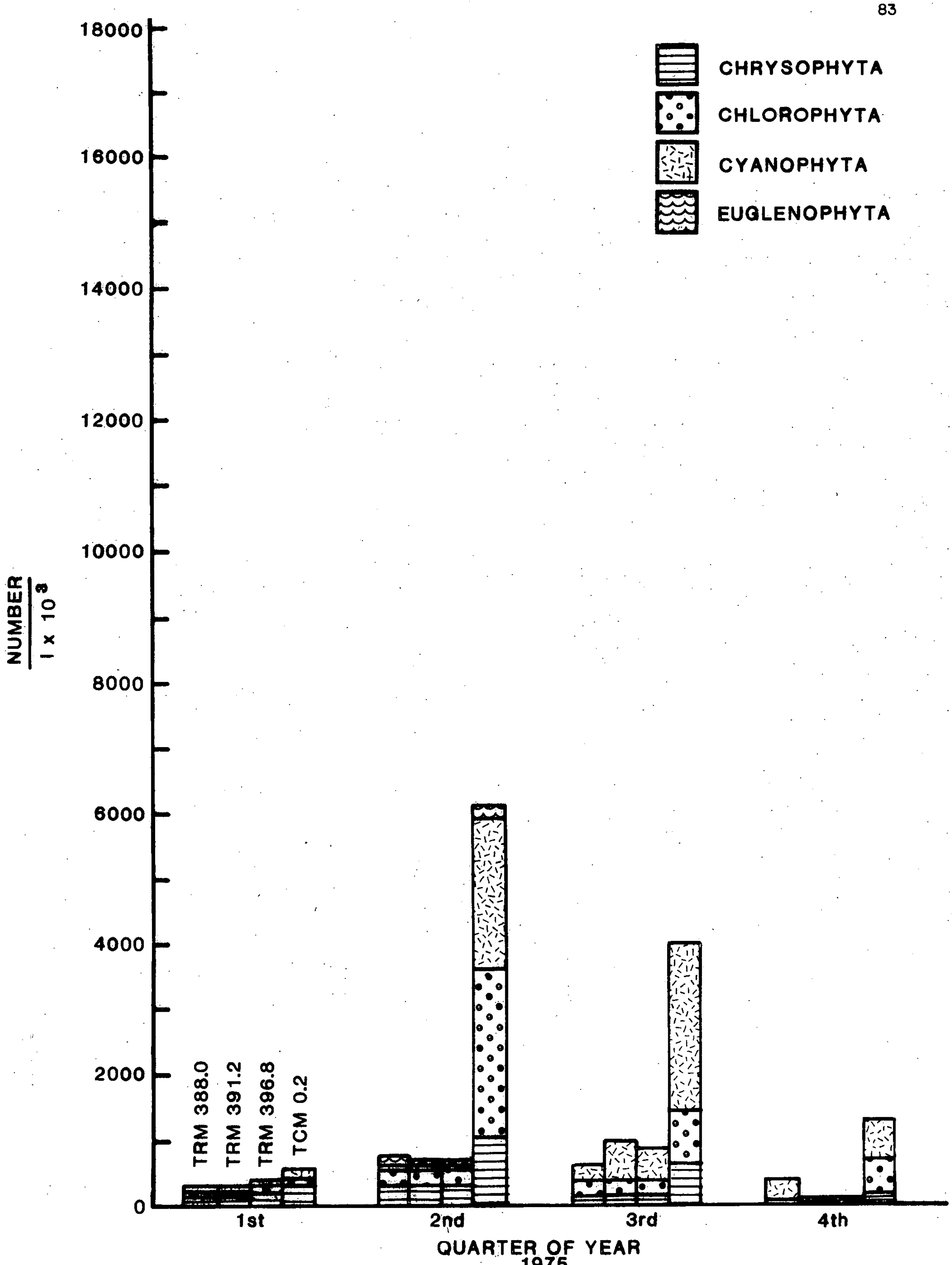


FIGURE 6.16

AVERAGE SEASONAL DENSITY OF THE PHYTOPLANKTON BY TAXONOMIC DIVISION IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

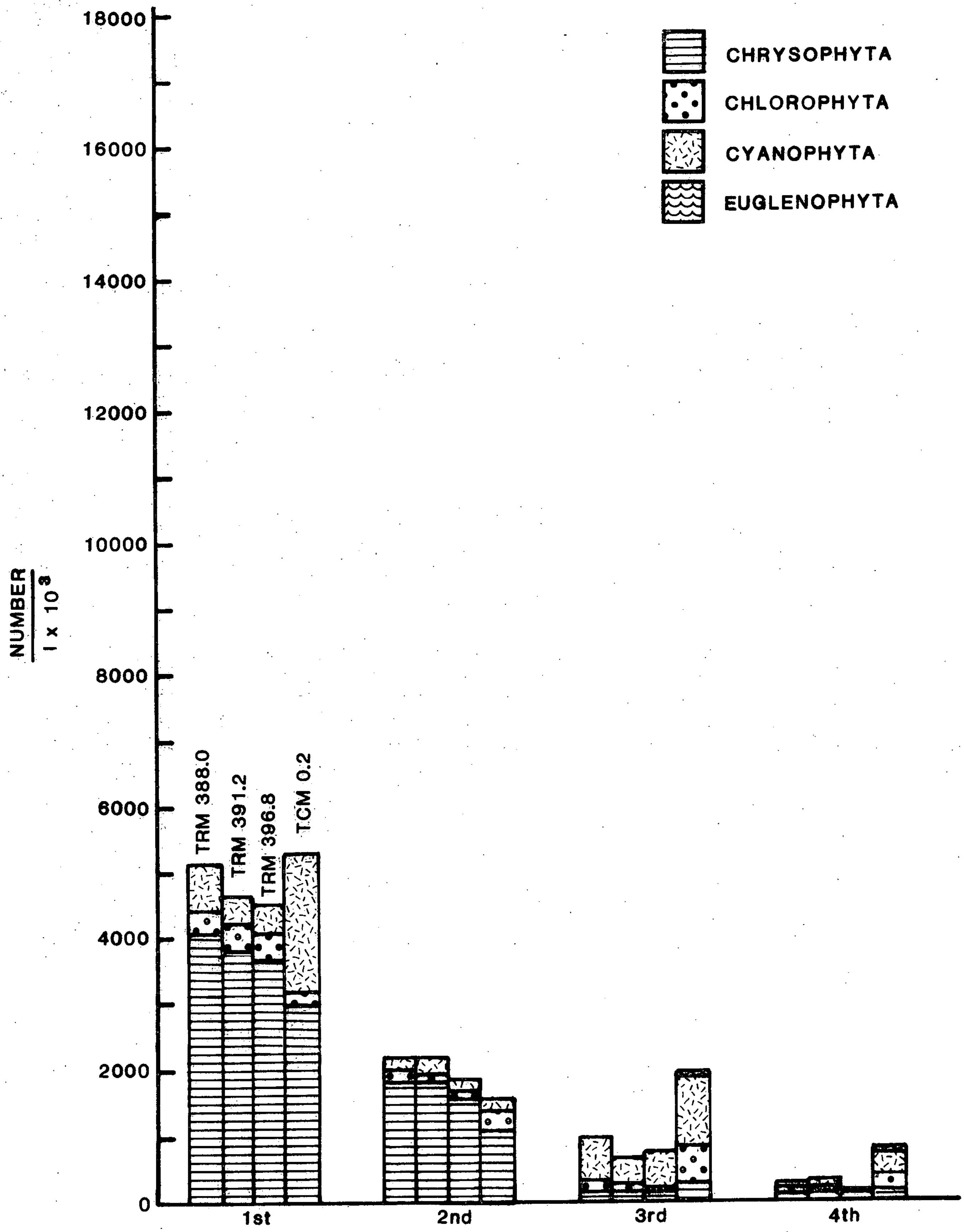


FIGURE 6.17

AVERAGE SEASONAL DENSITY OF THE PHYTOPLANKTON BY TAXONOMIC DIVISION IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

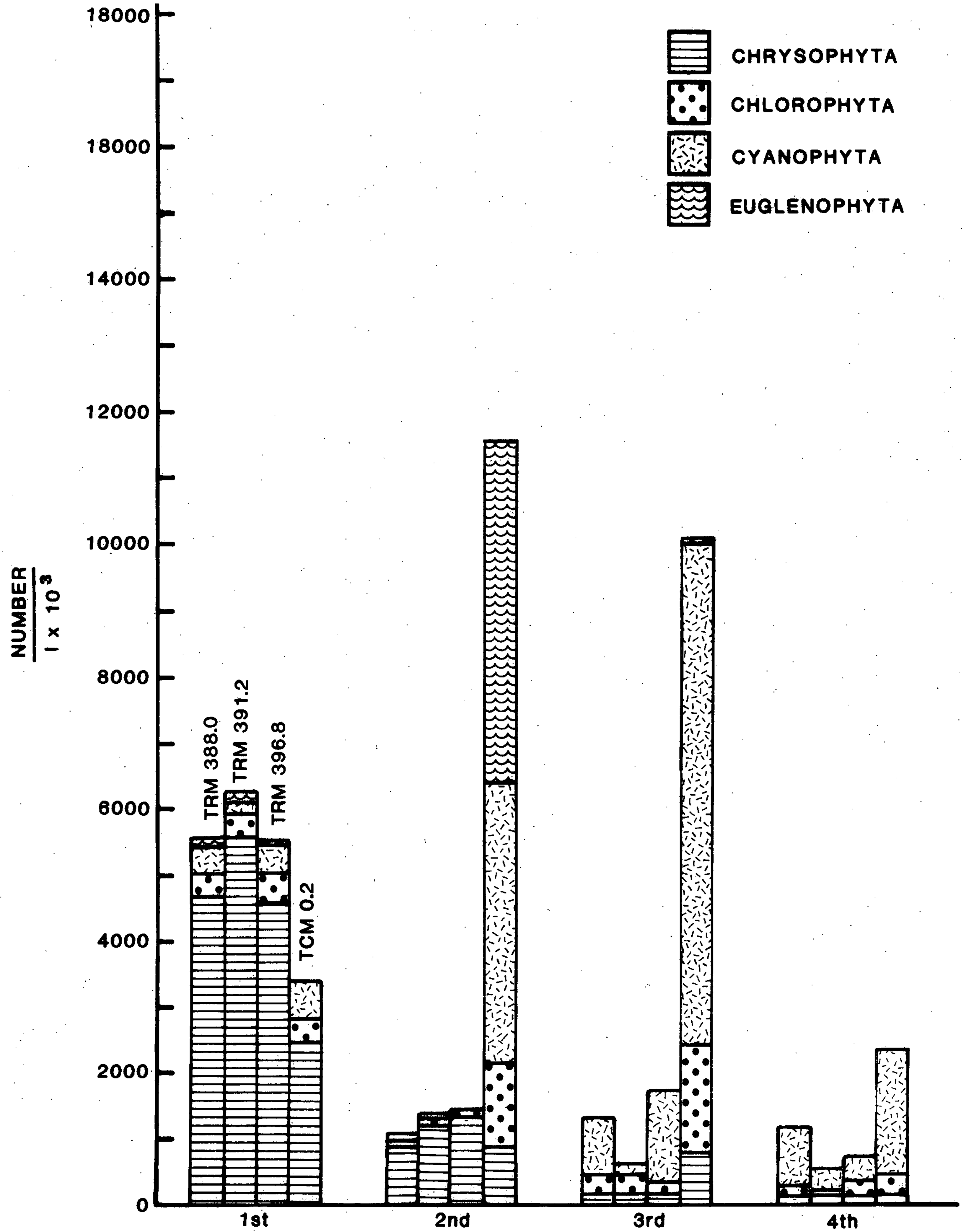
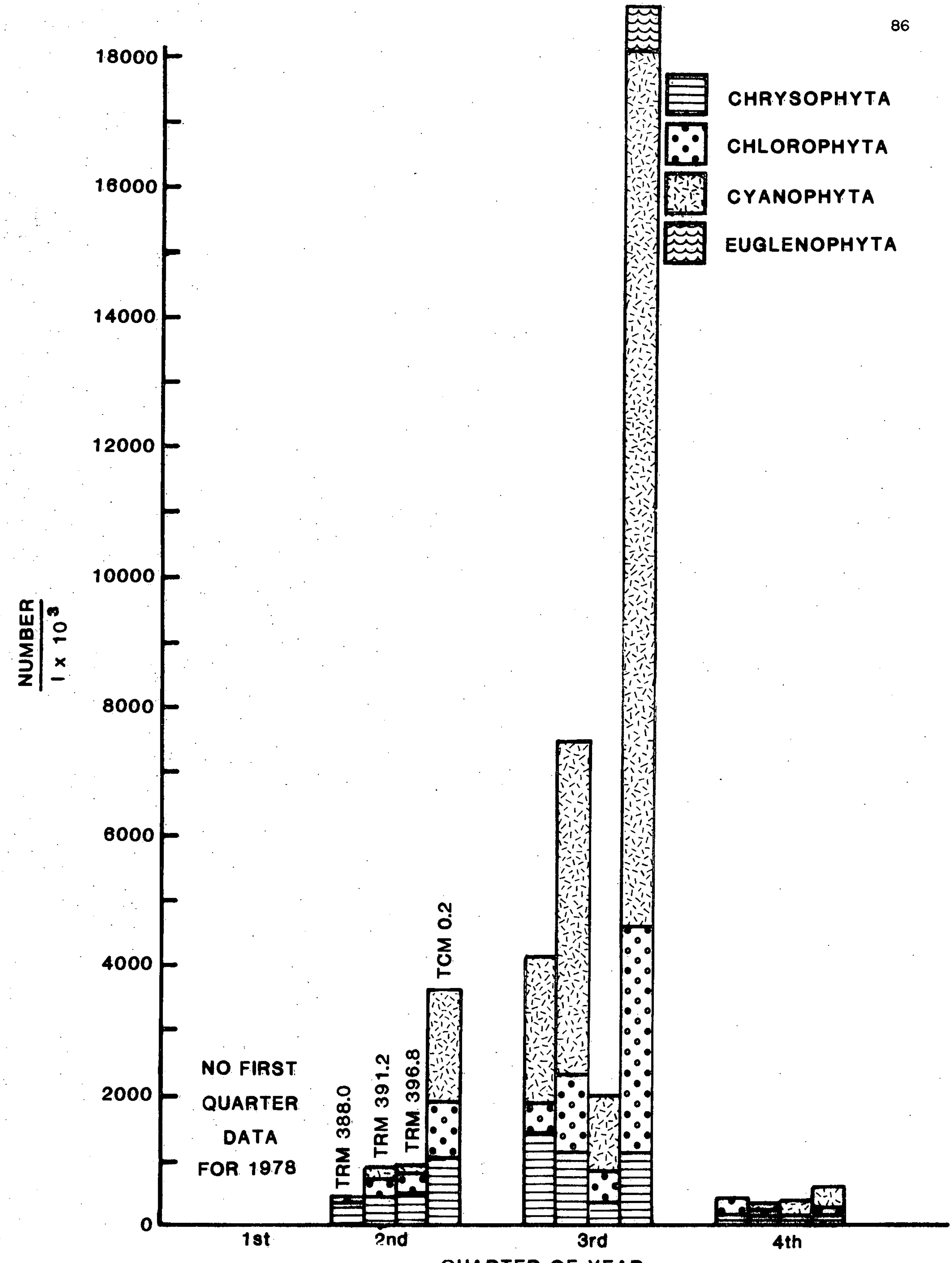


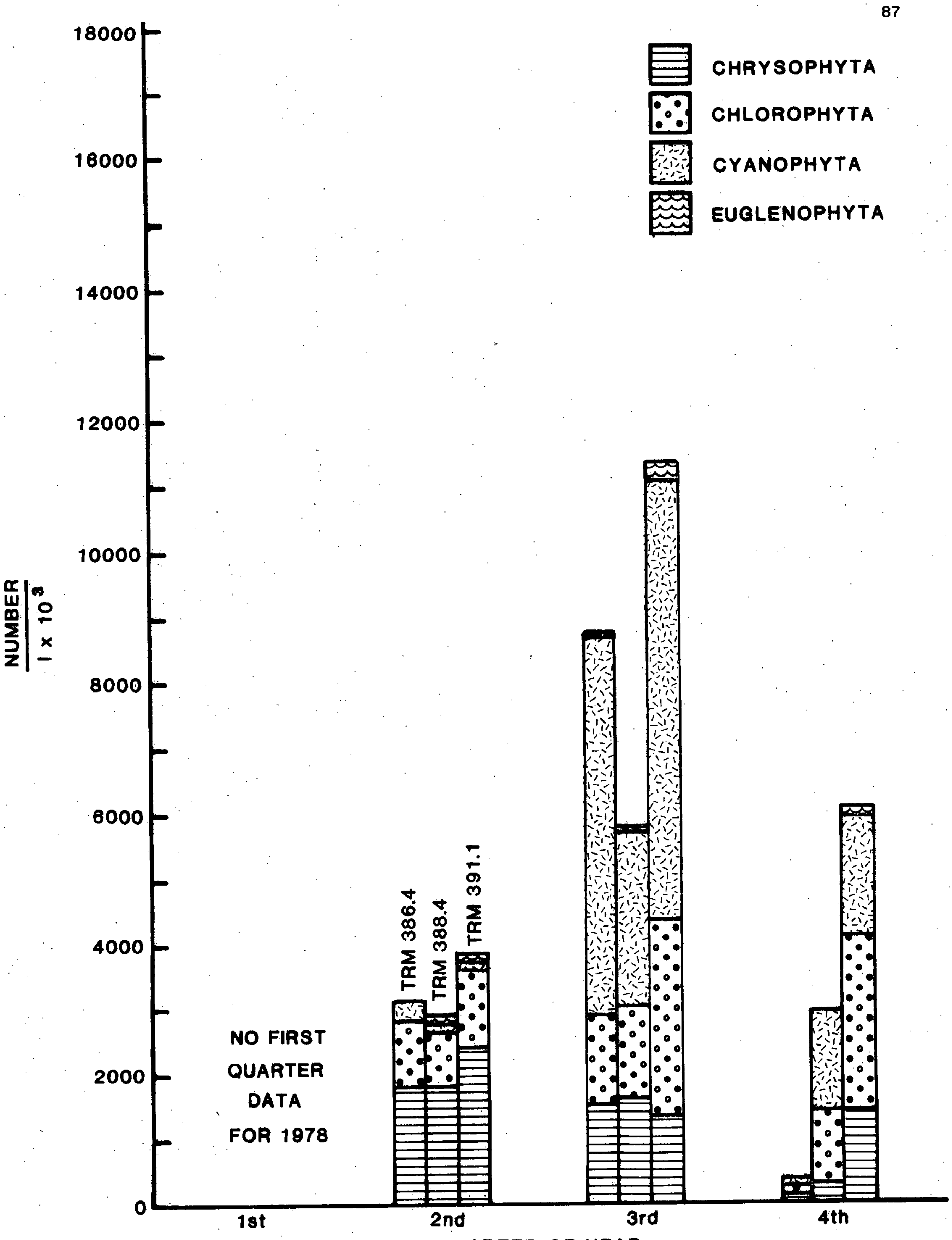
FIGURE 6.18

AVERAGE SEASONAL DENSITY OF THE PHYTOPLANKTON BY TAXONOMIC DIVISION IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT



1978 CHANNEL
FIGURE 6.19

AVERAGE SEASONAL DENSITY OF THE PHYTOPLANKTON BY TAXONOMIC DIVISION IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT



1978 OVERBANK
FIGURE 6.20

AVERAGE SEASONAL DENSITY OF THE PHYTOPLANKTON BY TAXONOMIC DIVISION IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

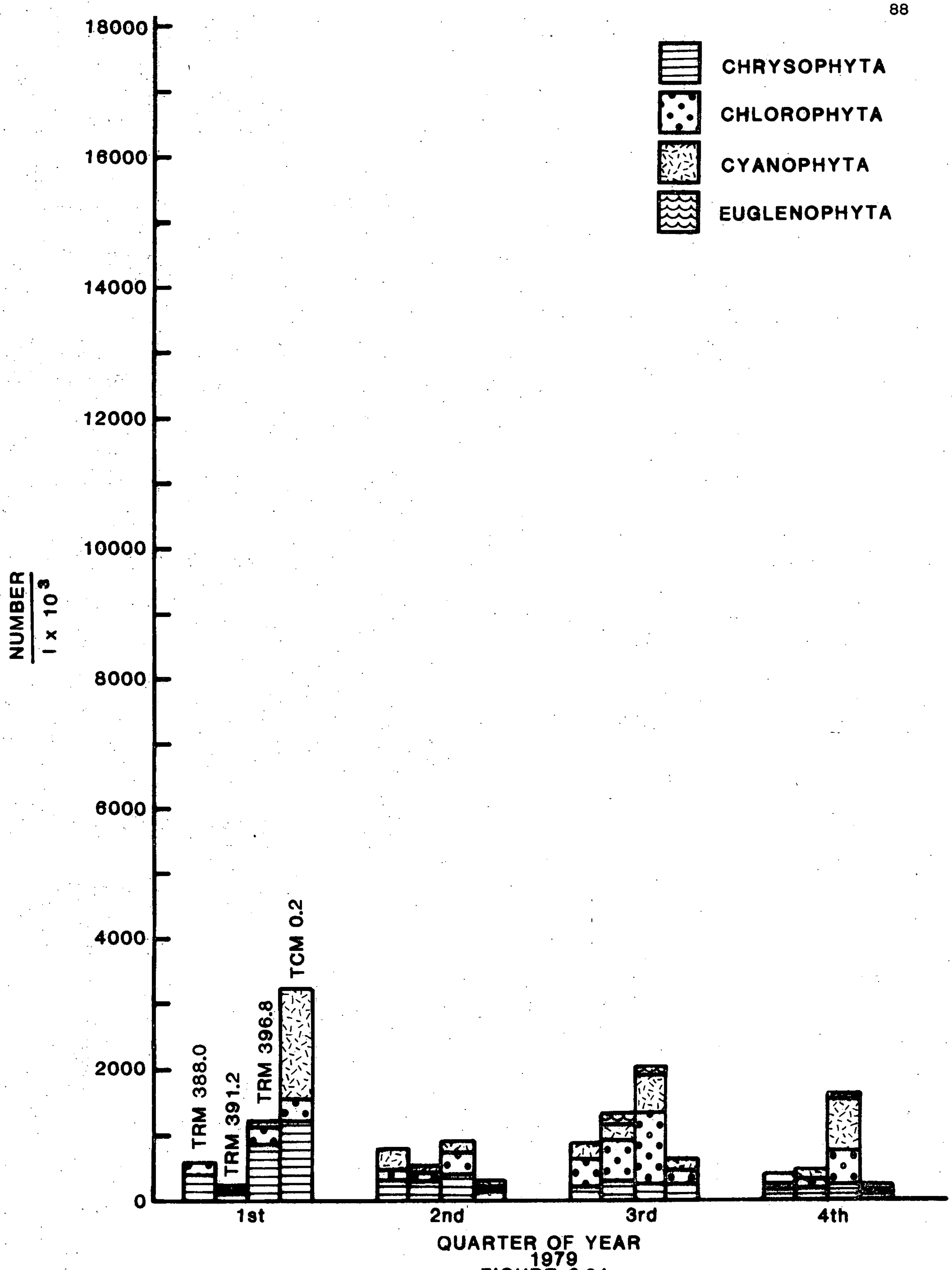


FIGURE 6.21

AVERAGE SEASONAL DENSITY OF THE PHYTOPLANKTON BY TAXONOMIC DIVISION IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

Figure 6.22 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Tennessee River Mile 388.0 (Channel), 1974-1978

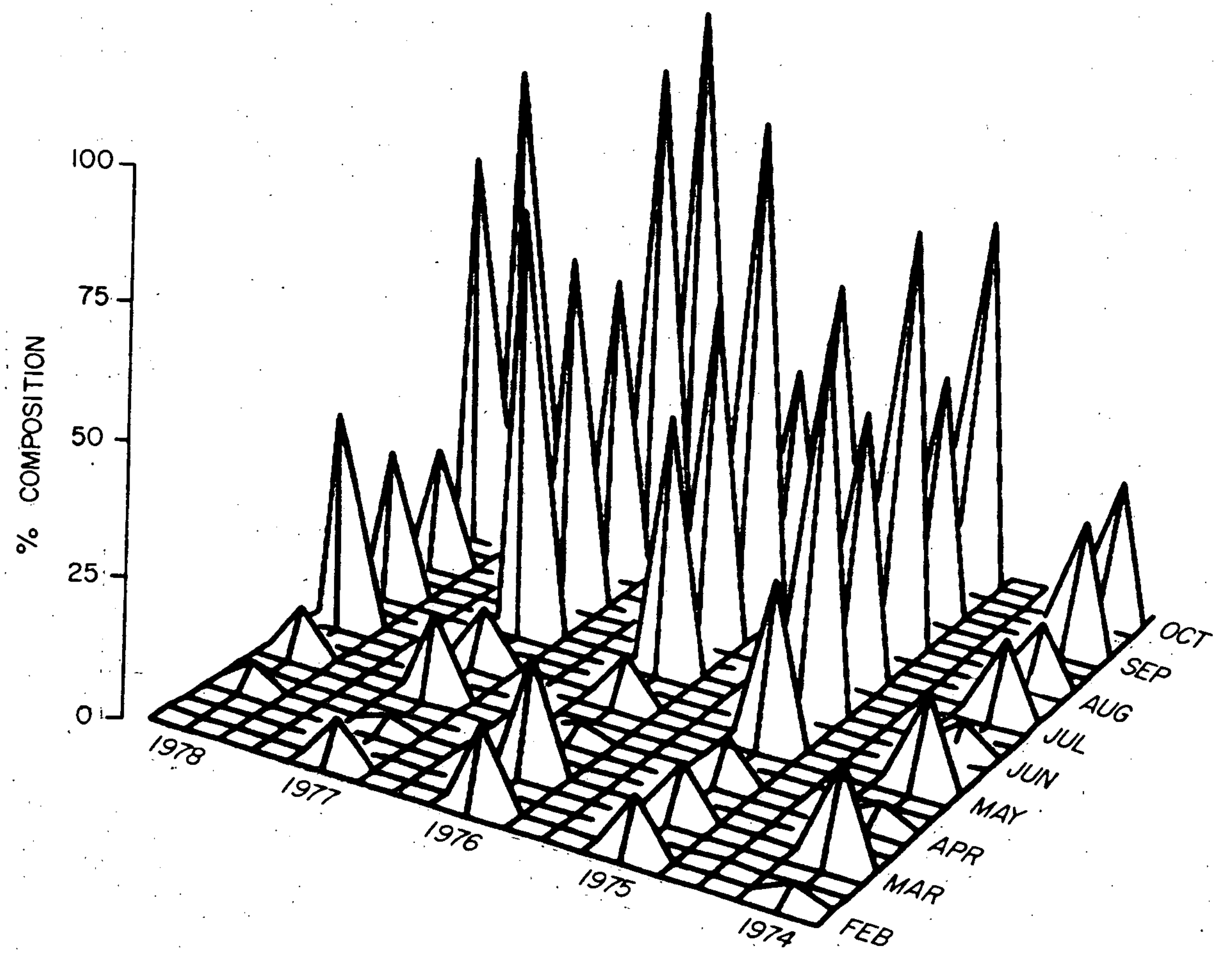


Figure 6.23 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Tennessee River Mile 391.2 (Channel), 1974-1978

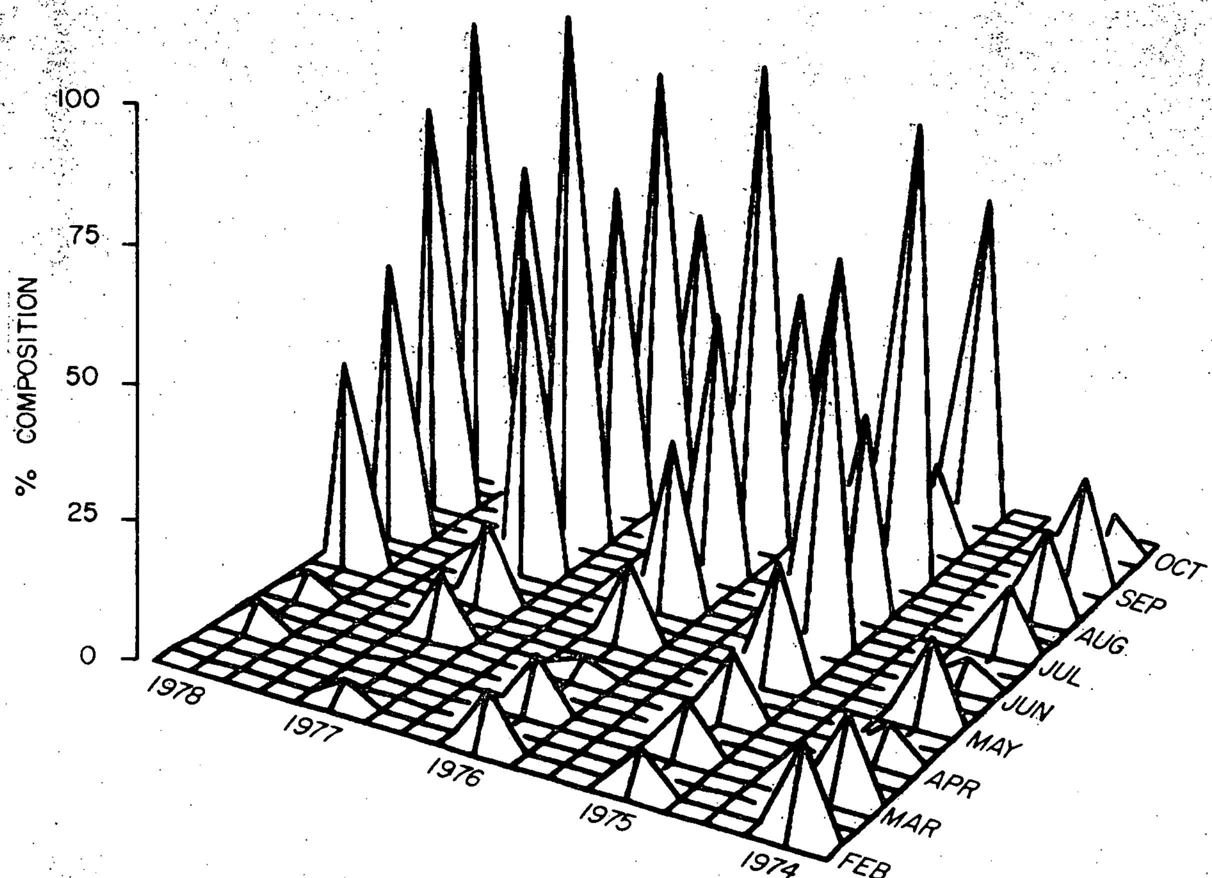
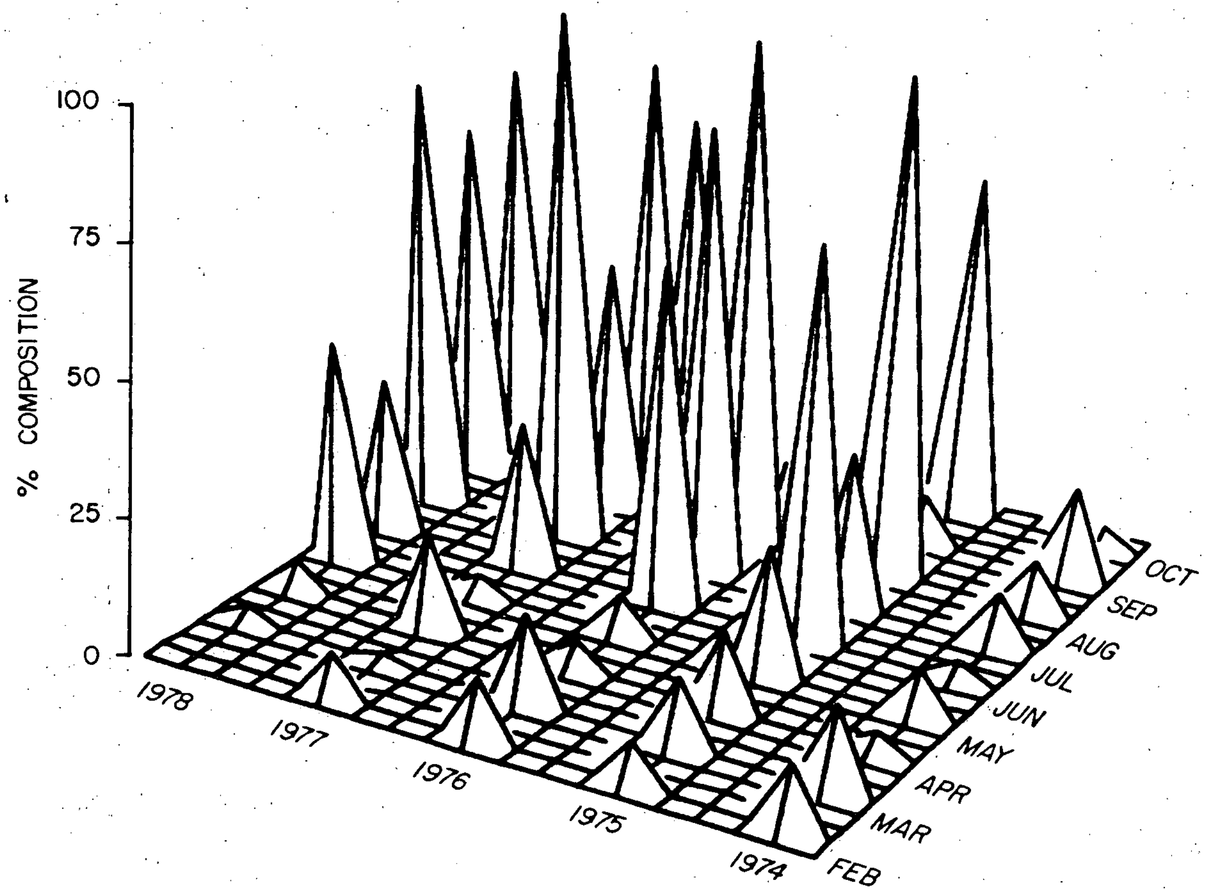


Figure 6.24 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Tennessee River Mile 396.8 (Channel), 1974-1978



POOR ORIGINAL

Figure 6.25 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Town Creek Mile 0.2, 1974-1978

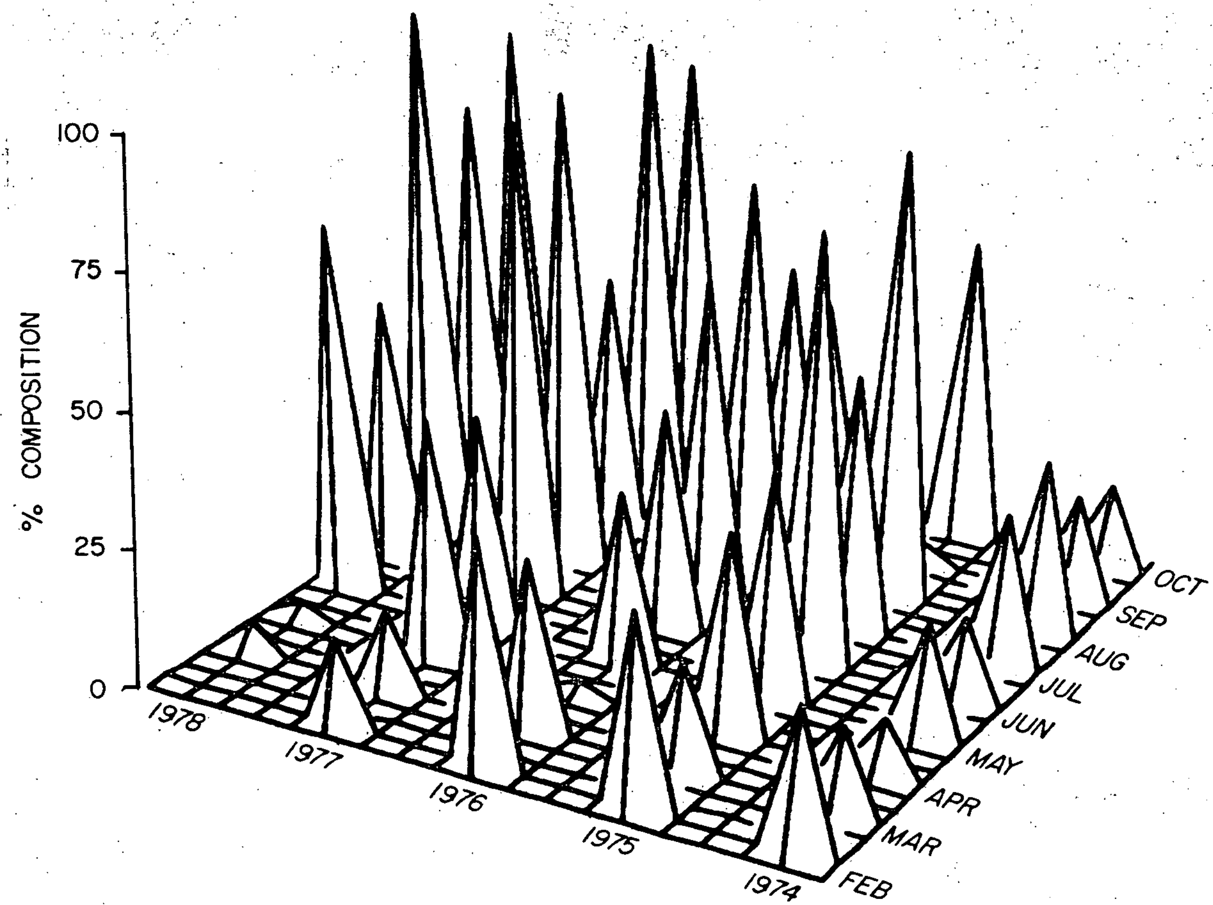


Figure 6.26 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Tennessee River Mile 391.1 (Overbank), 1978-1979

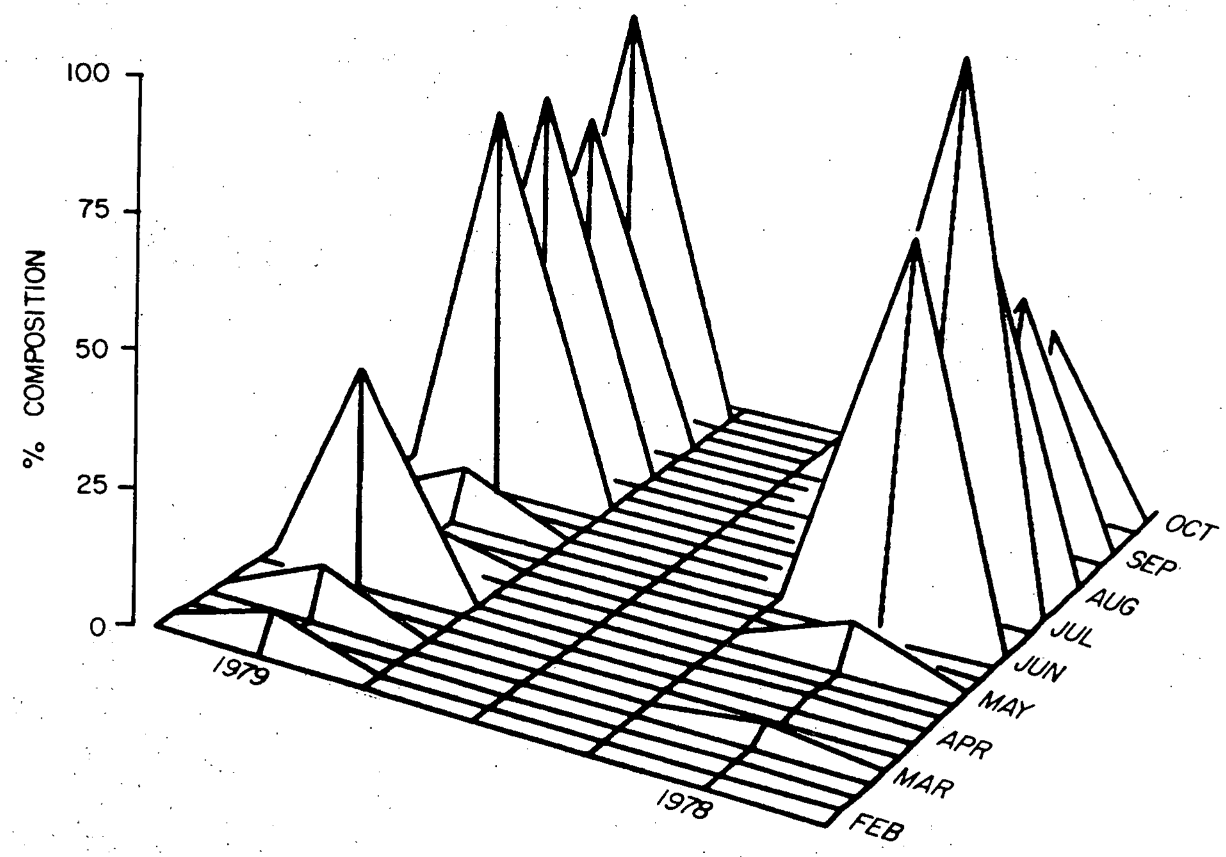


Figure 6.27 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Tennessee River Mile 386.4 (Overbank), 1978-1979

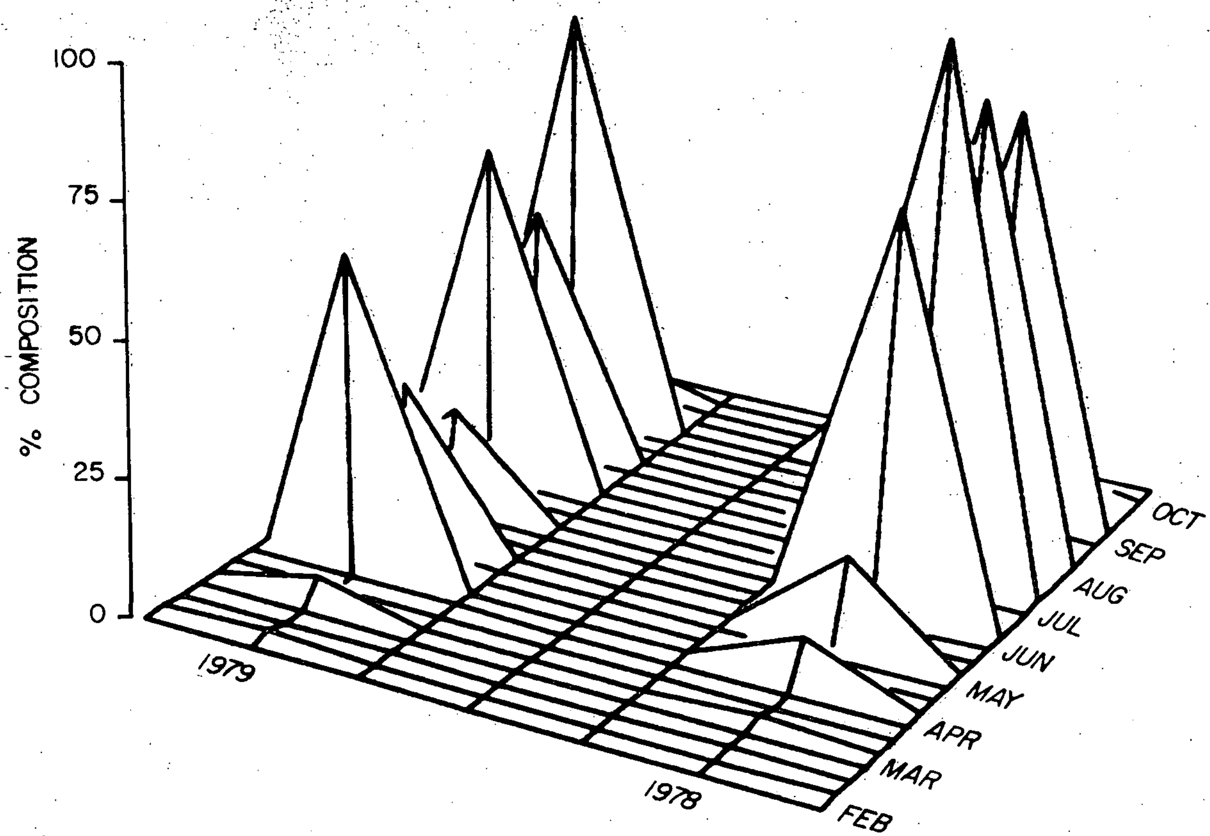


Figure 6.28 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Tennessee River Mile 388.4 (Overbank), 1978-1979

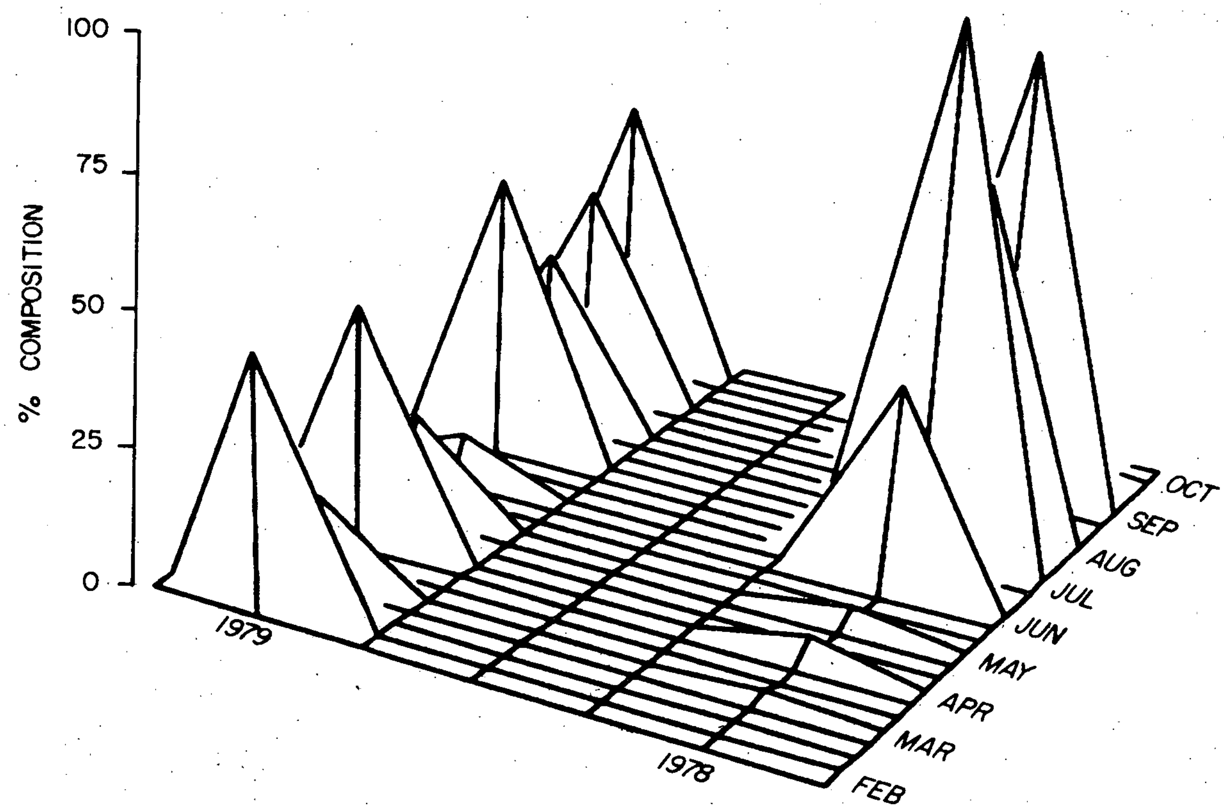


Figure 6.29 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Channel Locations Upstream and Downstream from Bellefonte Nuclear Plant, 1974

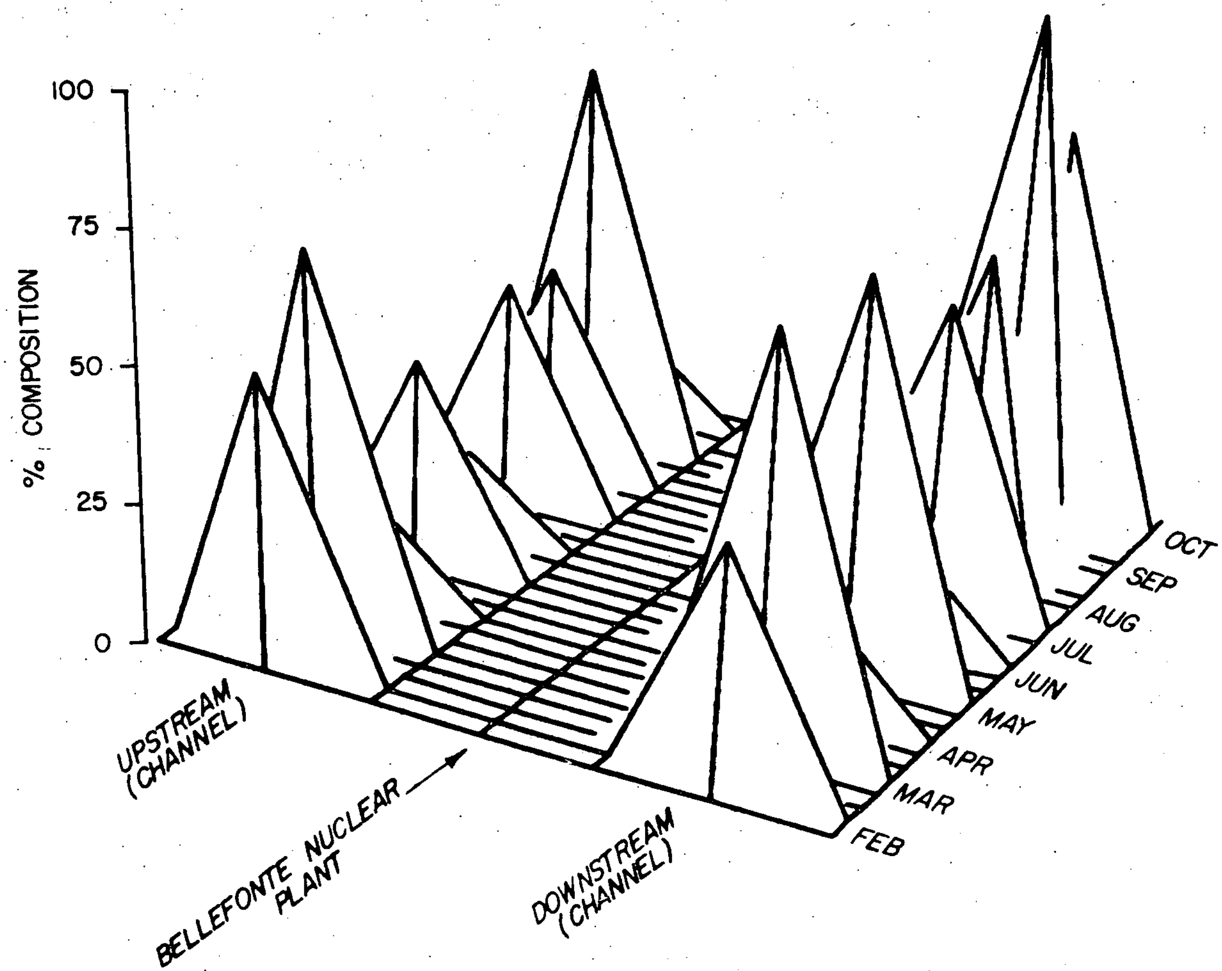


Figure 6.30 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Channel Locations Upstream and Downstream from Bellefonte Nuclear Plant, 1975

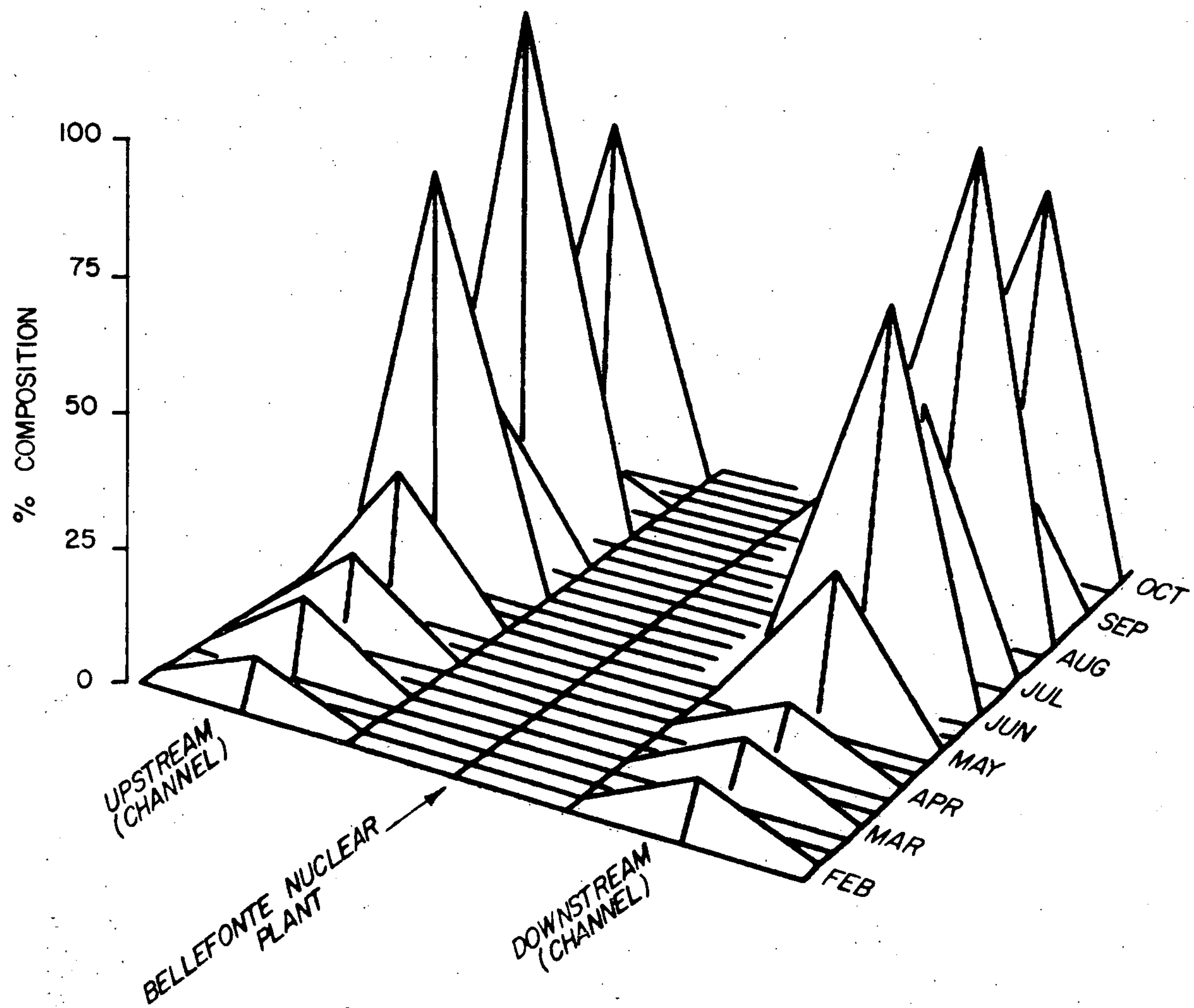


Figure 6.31 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Channel Locations Upstream and Downstream from Bellefonte Nuclear Plant, 1976

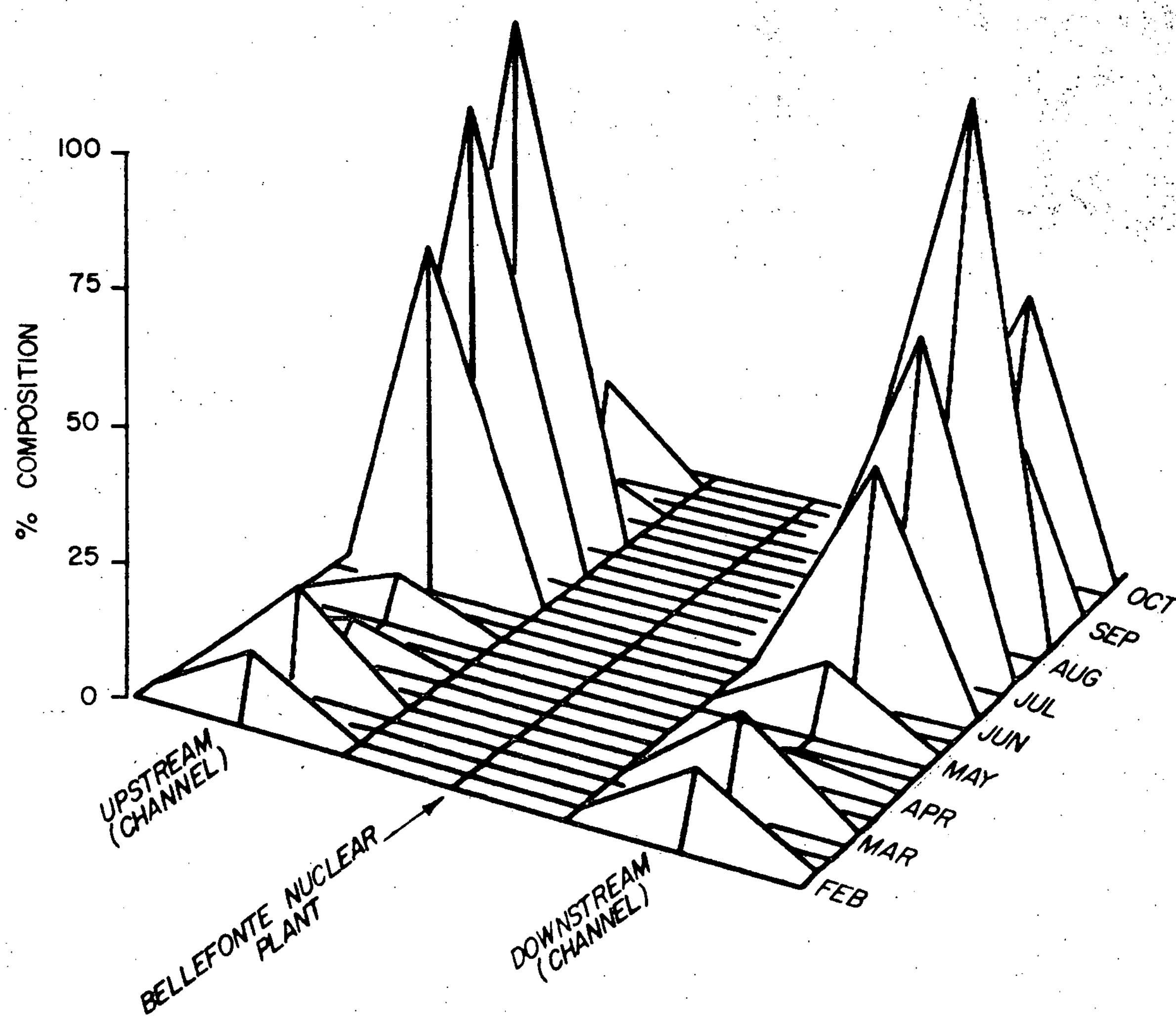


Figure 6.32 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Channel Locations Upstream and Downstream from Bellefonte Nuclear Plant, 1977

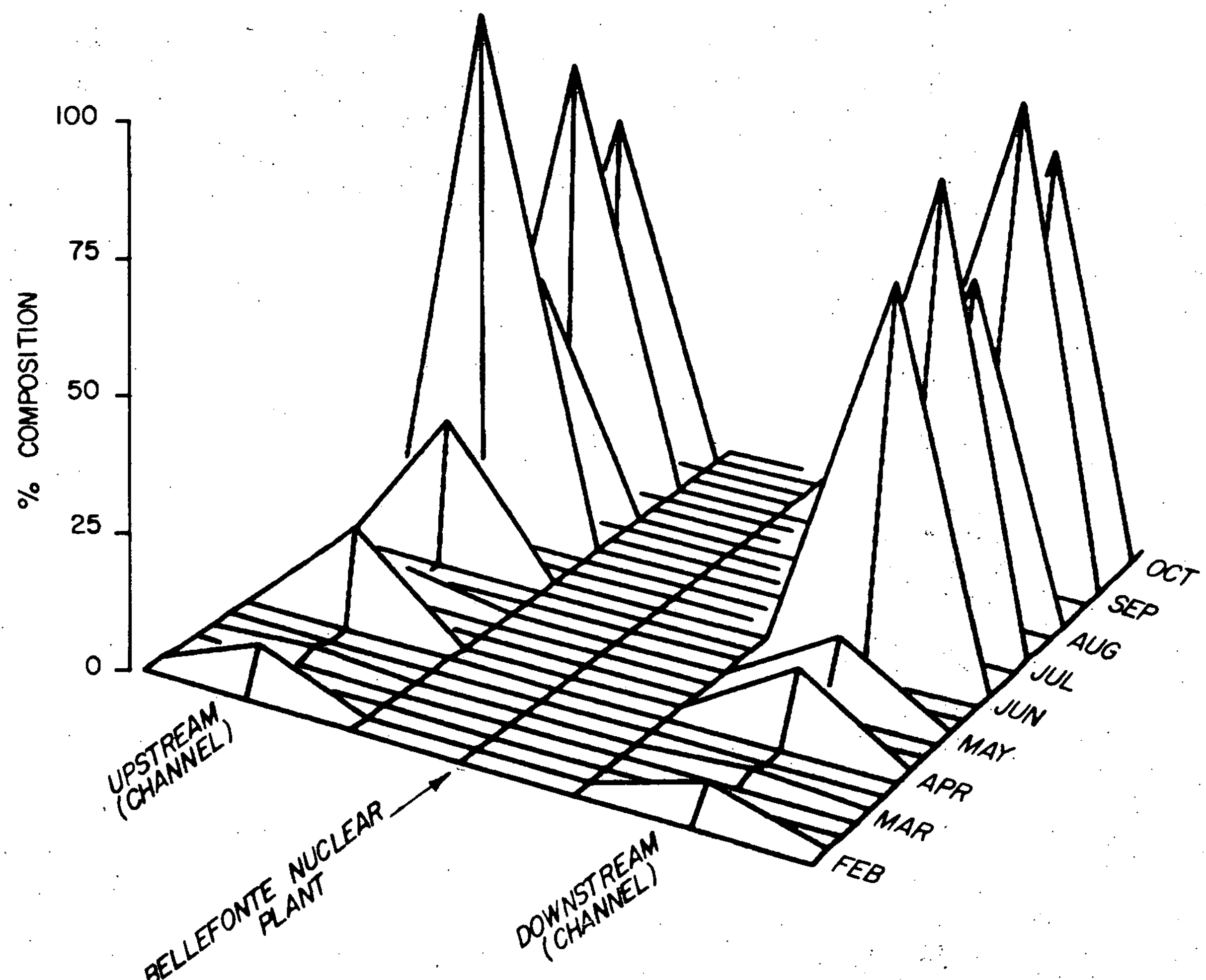


Figure 6.33 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Channel Locations Upstream and Downstream from Bellefonte Nuclear Plant, 1978

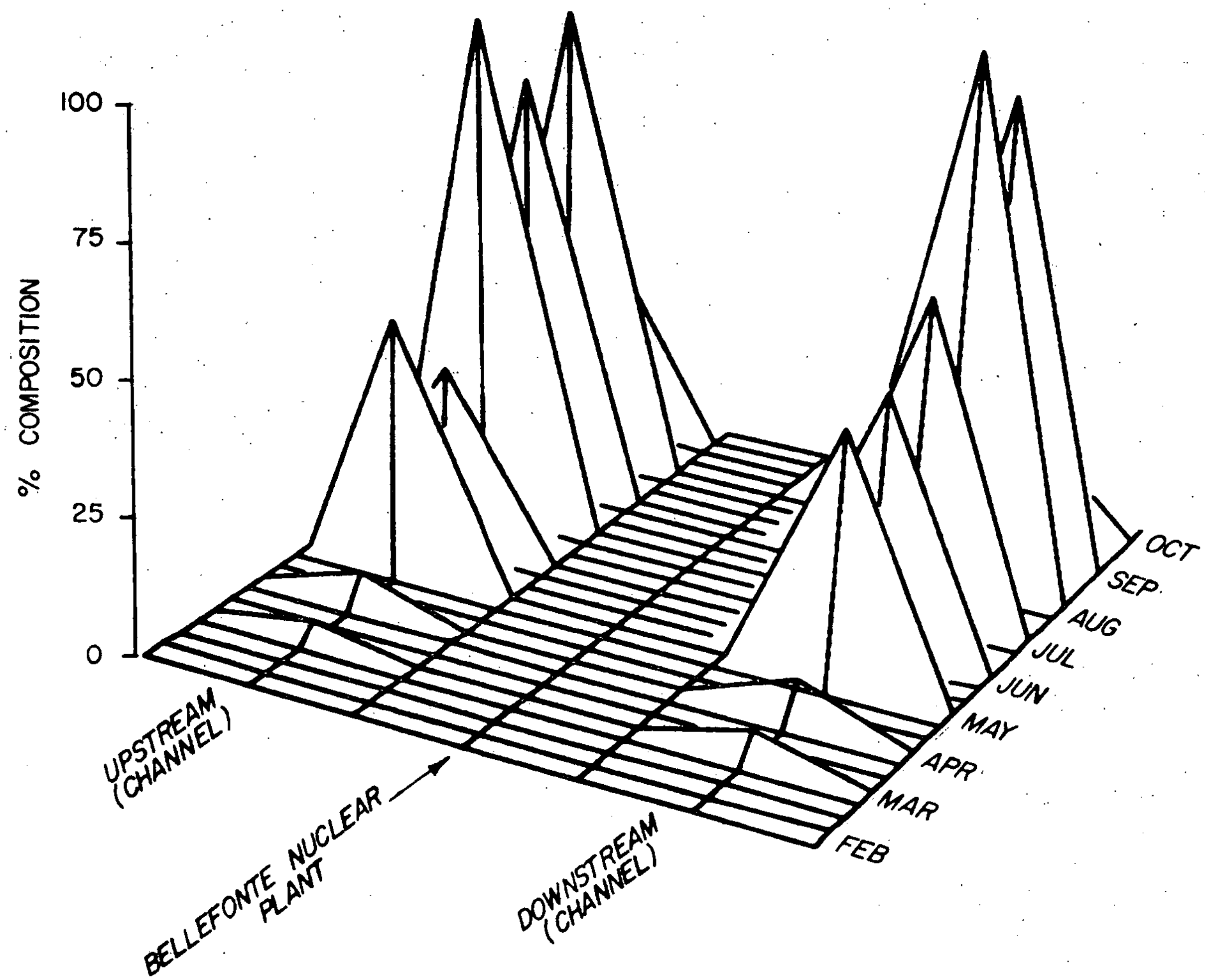


Figure 6.34 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Overbank Locations Upstream and Downstream from Bellefonte Nuclear Plant, 1978

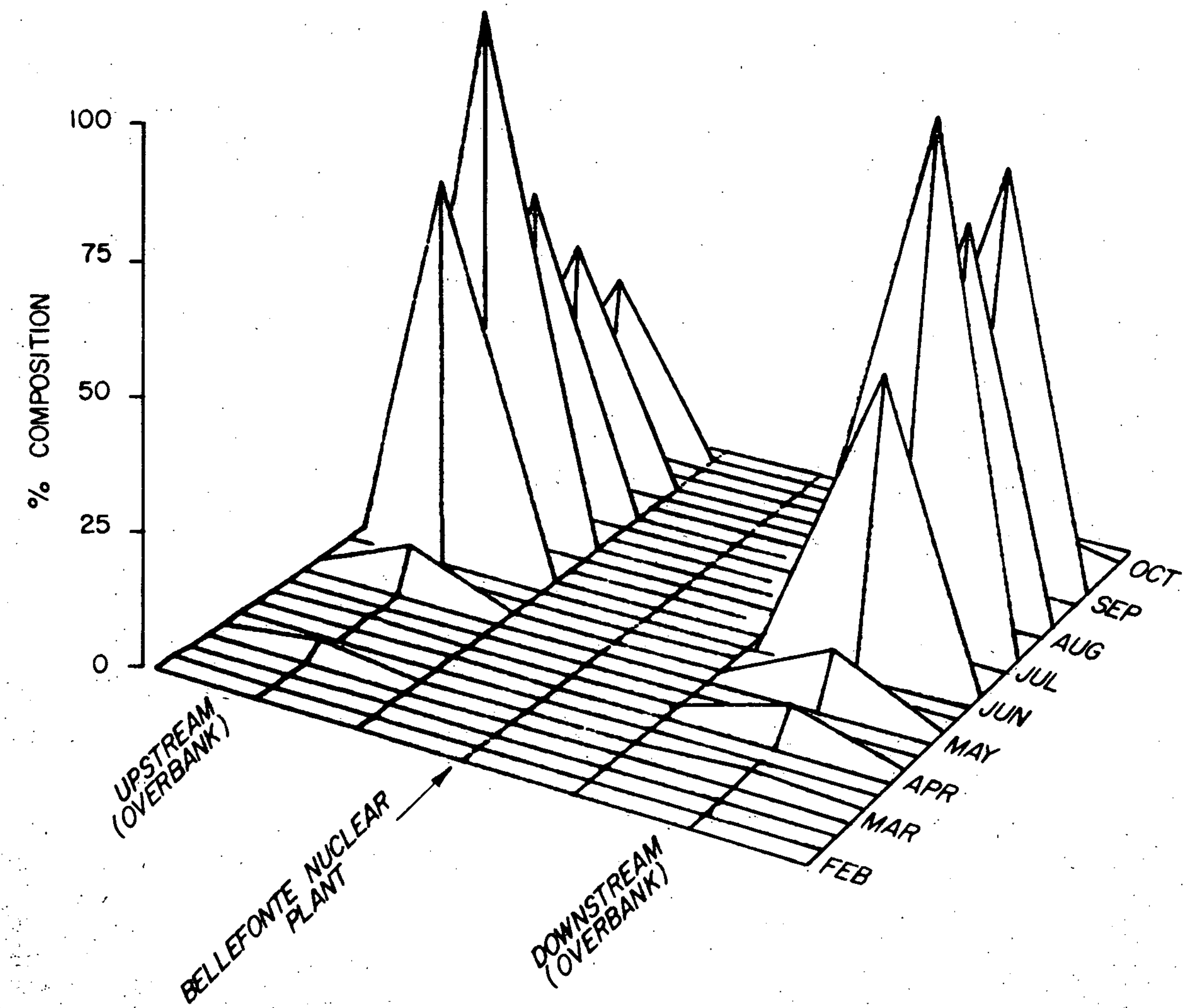
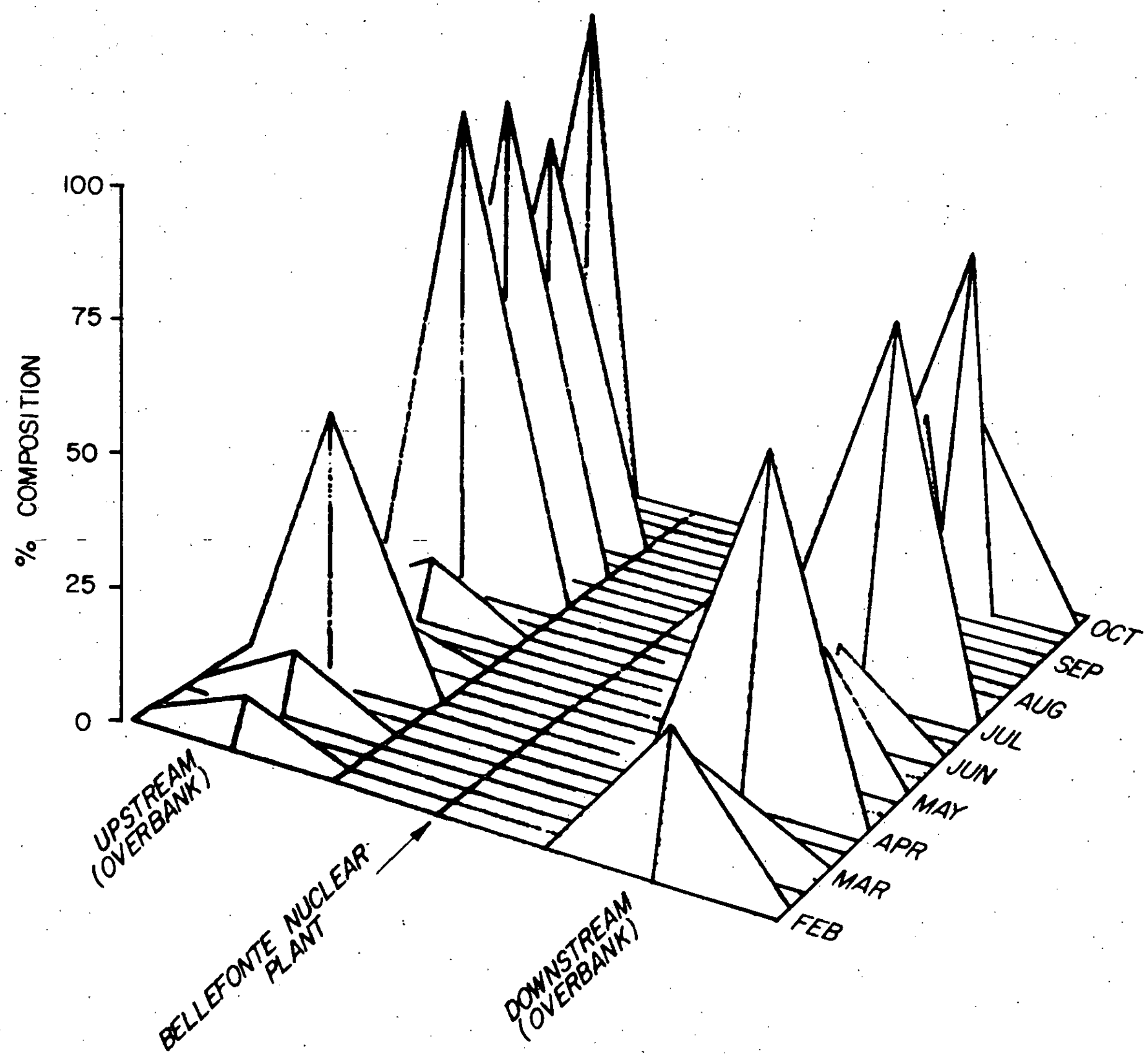


Figure 6.35 Percentage of the Phytoplankton Assemblage Composed of Blue-Green Algae (Cyanophyta) at Overbank Locations Upstream and Downstream from Bellefonte Nuclear Plant, 1979



7.0 AUFWUCHS

Introduction

An aufwuchs community is composed of an assemblage of organisms that includes, but is not limited to, algae, protozoans, rotifers, bacteria, fungi, and other minute organisms. They grow on the surface of underwater substrates and include autotrophs and heterotrophs. These two groups of organisms have unique characteristics which make them important in the study of water quality. First, autotrophic organisms use the sun's radiant energy and inorganic nutrients in the water to produce and store food energy. They can be the major source of primary production in streams since rapid turbulent flow is generally unfavorable for the maintenance of a phytoplankton community. The heterotrophic organisms, which include fungi, bacteria, rotifers, crustaceans, and protozoans, use the food energy produced by the autotrophic organisms. Secondly, environmental perturbations such as organic loading, temperature changes, or other ecological factors can cause a shift in dominance from autotrophs to heterotrophs. Because of these characteristics, the periphyton community (i.e., the autotrophic component of the aufwuchs) in Guntersville Reservoir near BNP was evaluated. The autotrophic-heterotrophic relationship known as the Autotrophic Index (AI) was determined and the taxonomic composition of the periphytic algal community was described qualitatively and quantitatively.

Methods and Materials

Field--Five plexiglass slides (5-mm thick, with an exposed area of 1.5 dm^2) were placed in a metal support rack and suspended vertically 0.5 m (two at each station) below the surface at TCM 0.2 and TRM's 388.0, 391.2, and 396.8. The plates were left to "colonize" for approximately one month and then removed. After removal, each plexiglass plate was placed in an individual plastic bag, labeled, iced, and returned to the laboratory and stored in a freezer.

Laboratory--Algal cells were scraped from two plates, placed in distilled water, diluted to 100 to 300 ml depending on density of periphytic growth, and agitated until the algal cells were dispersed. Four ml of thimerosal preservative was added to each 100 ml of sample. Fifteen milliliters from each agitated sample were poured into a counting chamber and allowed to settle for at least 12 hours. Periphyton was identified and enumerated at the generic level with an inverted microscope (magnification of 320X). Percentage composition of algal divisions was calculated.

Laboratory--Autotrophic Index--Four plates from each station were thawed and periphyton scraped from each plate, placed in a vial containing either 95 percent alcohol (1974) or aceone (1975-1978), homogenized and allowed to steep for three hours. The samples were filtered through preweighed filters and the filtrate from each was retained for phytopigment analysis on a Klett-Summerson colorimeter.

The filter and the residue were placed in a porcelain crucible and dried at 105°C for a minimum of 12 hours, or until a constant weight (I = 0.5) was obtained. The samples were then incinerated in a muffle furnace at 600°C for 1 hour, cooled in a dessicator, rewetted with distilled water and dried at 105°C. The samples were again cooled in a dessicator and weighed to calculate ash-free organic weight.

The chlorophyll _a_ and biomass were calculated in milligrams per square meter and substituted in the formula to compute the AI.

$$AI = \frac{\text{Biomass (mg/m}^2\text{)}}{\text{Chl } \underline{a} \text{ (mg/m}^2\text{)}}$$

Results

Periphytic distribution data are shown in appendix H. Illustrations of numbers of phytoplankton taxa by year and station are shown in figures 7.1 to 7.5. Genera that occurred most often were _Achnanthes_, _Cocconeis_, _Cymbella_, _Gomphonema_, _Melosira_, _Navicula_, _Synedra_, _Cosmarium_, _Stigeoclonium_, and _Oscillatoria_. In table 7.1 the genera are listed under major divisions and include 31 Chrysophyta, 43 Chlorophyta, 15 Cyanophyta, 3 Euglenophyta, 4 Pyrrhophyta, and 1 Cryptophyta for a total of 97 genera. The total number of genera that occurred at the stations ranged from a high of 35 at TRM 396.8 in 1978 to a low of 14 at TRM 388.0 in 1974. Fewer genera occurred in 1974 than during the rest of the monitoring period.

The number of genera collected at each station is summarized below:

Year	Total Number of Periphyton Taxa TRM 388.0	TRM 391.2	TRM 396.8	TCM 0.2
1974	14	16	15	22
1975	23	26	31	24
1976	26	26	23	26
1977	26	33	25	28
1978	27	28	35	33

Major divisions of periphyton were enumerated and are shown in appendix I and illustrated in figures 7.6 to 7.10. Chrysophyta was the dominant division, with Chlorophyta, Cyanophyta, Euglenophyta, and Pyrrhophyta following in decreasing order of abundance. The mean standing crop values ranged from 7693 x $10^6/m^2$ at TRM 396.8 in June 1976, to 103 x $10^6/m^2$ at TRM 391.2 in July 1978. Standing crop data did not reveal any trends in differences between stations.

Mean AI data are shown in table 7.2 and cover the period from 1974 through 1979. The data collected in 1974 cannot be compared with data from subsequent years because of a change in methodology. All AI mean values exceeded 100 in 1975 and most of the values in 1976 were greater than 100. Only 7 readings in 1977 were greater than 100, but in 1978 there were 12 out of 27 readings that exceeded 100. Weber and McFarland (1969) and Weber (1973) have suggested that AI values exceeding 100 may indicate the presence of some organic pollution. Out of a possible 140 means in table 7.2, 23 could not be calculated because slides were not recovered due to vandalism or loss of artificial substrates. However, for the data available, no distinct trends were noted. Values obtained are similar to those observed on other TVA mainstream reservoirs (TVA 1979).

Literature Cited

Tennessee Valley Authority, 1979. Watts Bar Nuclear Plant Preoperational Aquatic Monitoring Report, 1973-1977. Tennessee Valley Authority, Division of Water Resources, Chattanooga, Tennessee. 172 pp.

Weber, E. I. and B. McFarland. 1969. "Periphyton Biomass--Chlorophyll Ratio as an Index to Water Quality." Presented at the 17th Annual Meeting, Midwest Benthological Soc., Gilbertsville, Kentucky, April 1969.

Weber, C. 1973. "Recent Developments in the Measurement of the Response of Phytoplankton and Periphyton to Changes in Their Environment." Bioassay Techniques and Environmental Chemistry," G. Class, ed., Ann Arbor Science Publishers, Inc. pp. 119-138.

Table 7.1

PERIPHYTON GENERA THAT COLONIZED SUBSTRATES IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - GUNTERSVILLE RESERVOIR 1974-1978

Chrysophyta
- Achnanthes
- Asterionella
- Attheya
- Caloneis
- Chaetoceros
- Cocconeis
- Cyclotella
- Cymatopleura
- Cymbella
- Diatoma
- Dinobryon
- Diploneis
- Eunotia
- Fragilaria
- Gomphonema
- Gyrosigma
- Mallomonas
- Melosira
- Meridion
- Navicula
- Nitzschia
- Pinnularia
- Pleurosigma
- Rhizosolenia
- Rhoicosphenia
- Stauroneis
- Stephanodiscus
- Surirella
- Synedra
- Synura
- Tabellaria

Total Taxa 31

Chlorophyta
- Actinastrum
- Ankistrodesmus
- Carteria
- Chlamydomonas
- Chlorella
- Chlorococcum
- Chodatella
- Closterium
- Coelastrum
- Cosmarium
- Crucigenia
- Dactylococcus
- Distyosphaerium
- Eudorina
- Gloeocystis
- Golenkinia
- Gonium
- Kirchneriella
- Micractinium
- Micrasterias
- Microspora
- Mougeotia
- Oedogonium
- Oocystis
- Pandorina
- Pediastrum
- Planktosphaeria
- Pleodorina
- Polyedriopsis
- Protococcus
- Scenedesmus
- Selenastrum
- Sphaerocystis
- Spirogyra
- Staurastrum
- Stigeoclonium
- Tetradesmus
- Tetraedon
- Tetraspora
- Tetrastrum
- Treubaria
- Ulothrix
- Volvox

Total Taxa 43

Cyanophyta
- Anabaena
- Anacystis
- Aphanizomenon
- Arthrospira
- Chroococcus
- Coelosphaerium
- Dactylococcopsis
- Gomphosphaeria
- Lyngbya
- Merismopedia
- Nostoc
- Ostillatoria
- Phormidium
- Raphidiopsis
- Spirulina

Total Taxa 15

Euglenophyta
- Euglena
- Phacus
- Trachelomonas

Total Taxa 3

Pyrrhophyta
- Ceratium
- Glenodinium
- Gymnodinium
- Peridinium

Total Taxa 4

Cryptophyta
- Heteromastix

Total Taxa 1

Total Number of Taxa 97

Table 7.2

PERIPHYTON AUTOTROPHIC INDEX VALUES[a] BY YEAR, MONTH, AND STATION
BELLEFONTE NUCLEAR PLANT

Colonization period	Station	Mean AI Values				
		1974[b]	1975	1976	1977	1978
March-April	TRM 388.0	83.04	204.76	276.52	c	10.58
	TRM 391.2	108.16	171.83	323.23	c	68.13
	TRM 396.8	185.40	147.62	c	114.14	73.51
	TCM 0.2	120.93	132.05	220.38	c	98.34
April-May	TRM 388.0	c	104.08	337.41	85.50	-
	TRM 391.2	c	112.83	223.50	128.42	151.99
	TRM 396.8	41.26	162.79	285.70	70.26	139.28
	TCM 0.2	53.30	c	c	55.63	90.24
May-June	TRM 388.0	68.36	c	146.22	99.70	226.09
	TRM 391.2	60.45	271.61	108.74	65.71	75.56
	TRM 396.8	84.39	241.01	255.89	117.41	306.59
	TCM 0.2	91.93	428.74	202.71	98.23	75.57
June-July	TRM 388.0	117.13	305.40	142.22	131.09	110.89
	TRM 391.2	102.63	274.57	75.55	94.17	145.83
	TRM 396.8	c	184.11	91.77	85.01	126.40
	TCM 0.2	145.35	312.50	95.65	175.80	82.05
July-August	TRM 388.0	102.00	c	197.60	77.23	62.57
	TRM 391.2	105.95	201.50	194.22	82.02	64.33
	TRM 396.8	c	287.65	251.75	39.90	82.82
	TCM 0.2	c	145.35	217.13	141.76	80.13
August-September	TRM 388.0	92.46	110.51	202.71	55.25	98.91
	TRM 391.2	69.05	127.95	301.47	c	109.78
	TRM 396.8	80.33	119.96	211.18	c	101.02
	TCM 0.2	150.91	c	221.92	c	253.42
September-October	TRM 388.0	95.53	c	512.34	74.62	104.01
	TRM 391.2	69.23	c	337.32	c	67.89
	TRM 396.8	55.44	c	44.63	82.45	76.09
	TCM 0.2	150.91	c	497.60	122.73	108.74

a. AI = Ash-free organic weight-chlorophyll a.

b. Algal pigments for 1974 were extracted with 95 percent ethyl alcohol; therefore, AI values may not be comparable with those for 1975-1978 (acetone extracted).

c. Samples not collected.

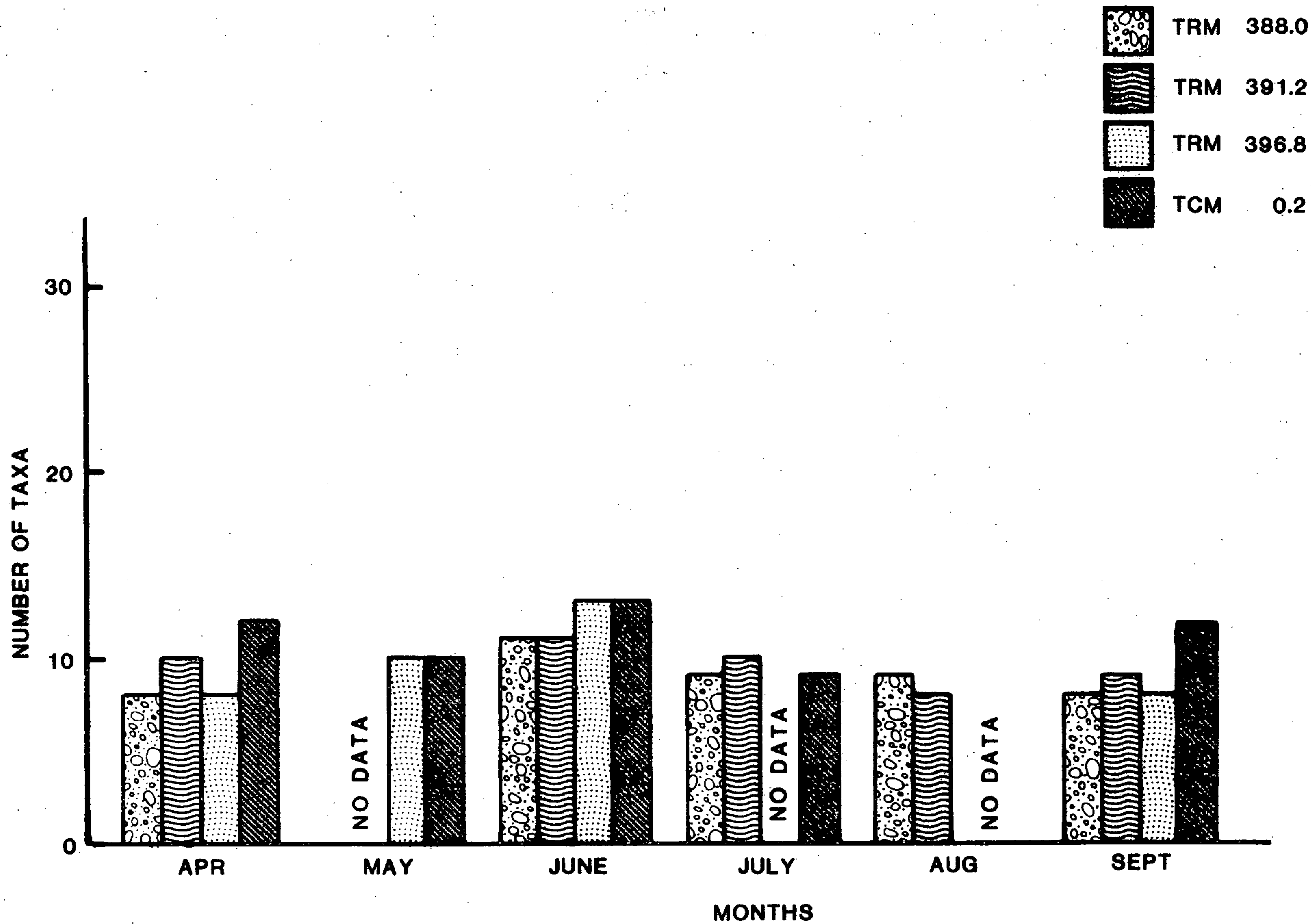


FIGURE 7.1

NUMBER OF PERIPHYTIC PHYTOPLANKTON TAXA THAT COLONIZED ARTIFICIAL SUBSTRATES IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT APRIL TO SEPTEMBER 1974

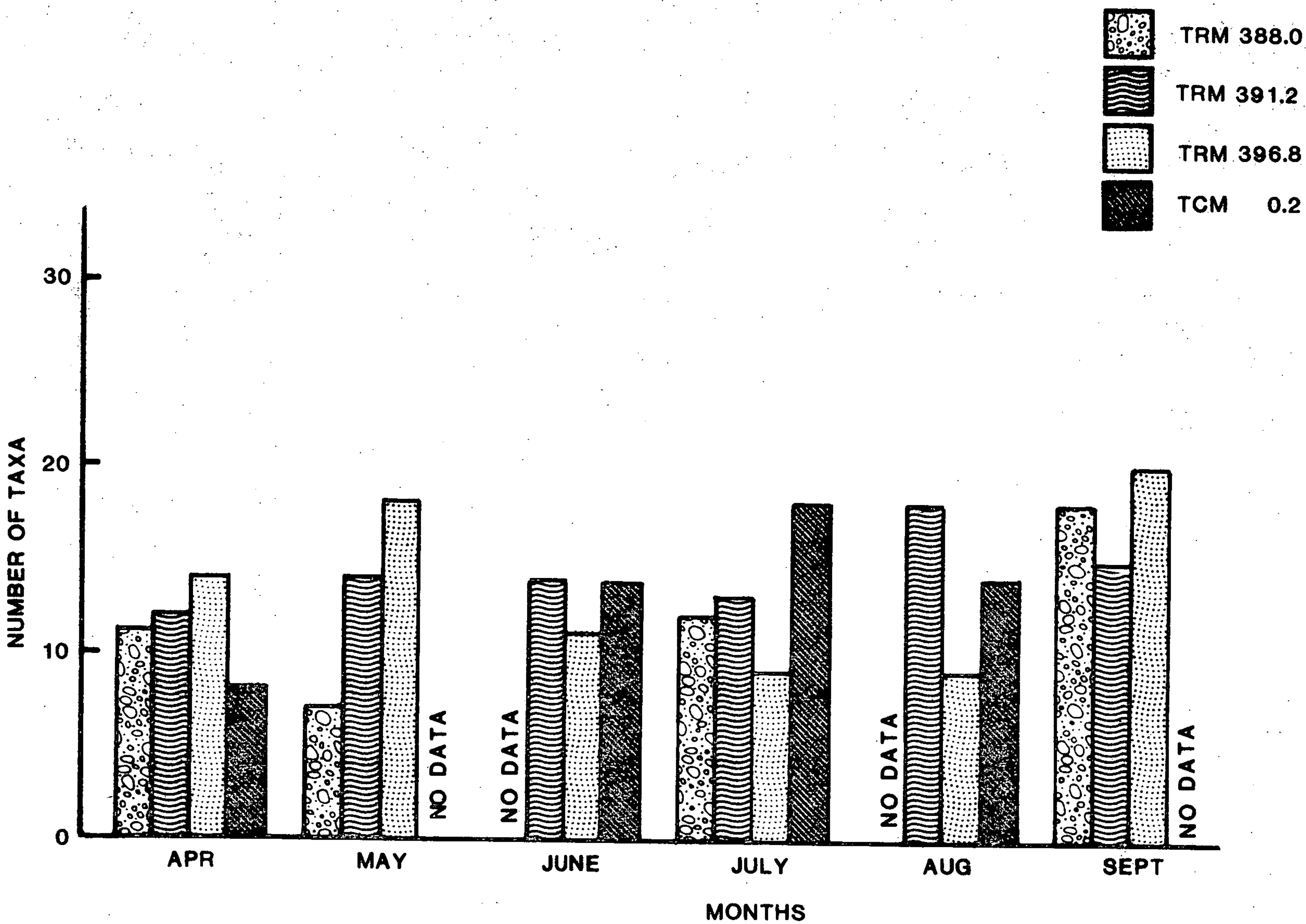


FIGURE 7.2

NUMBER OF PERIPHYTIC PHYTOPLANKTON TAXA THAT COLONIZED ARTIFICIAL SUBSTRATES IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT APRIL TO SEPTEMBER 1975

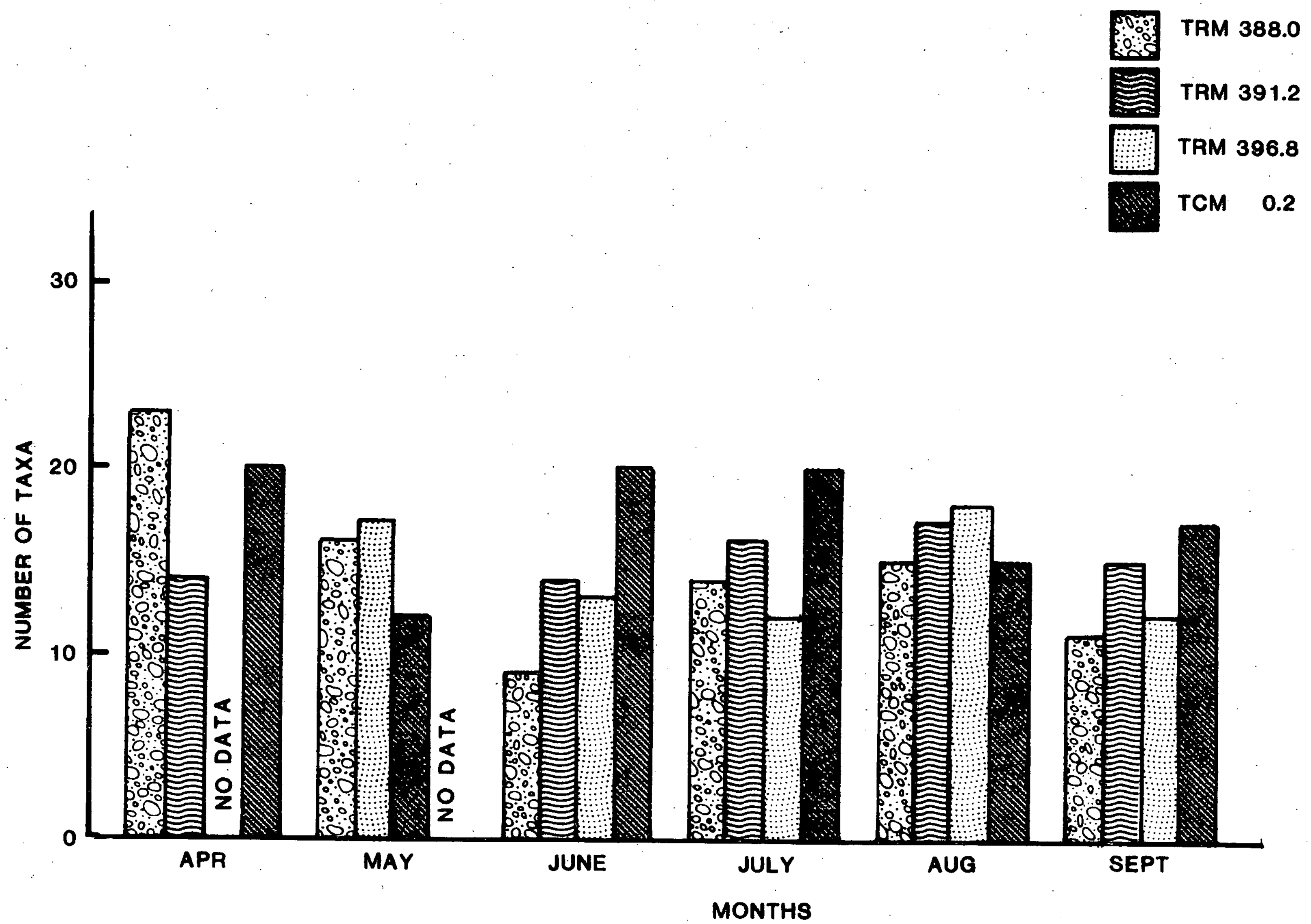


FIGURE 7.3

NUMBER OF PERIPHYTIC PHYTOPLANKTON TAXA THAT COLONIZED ARTIFICIAL SUBSTRATES IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT APRIL TO SEPTEMBER 1976

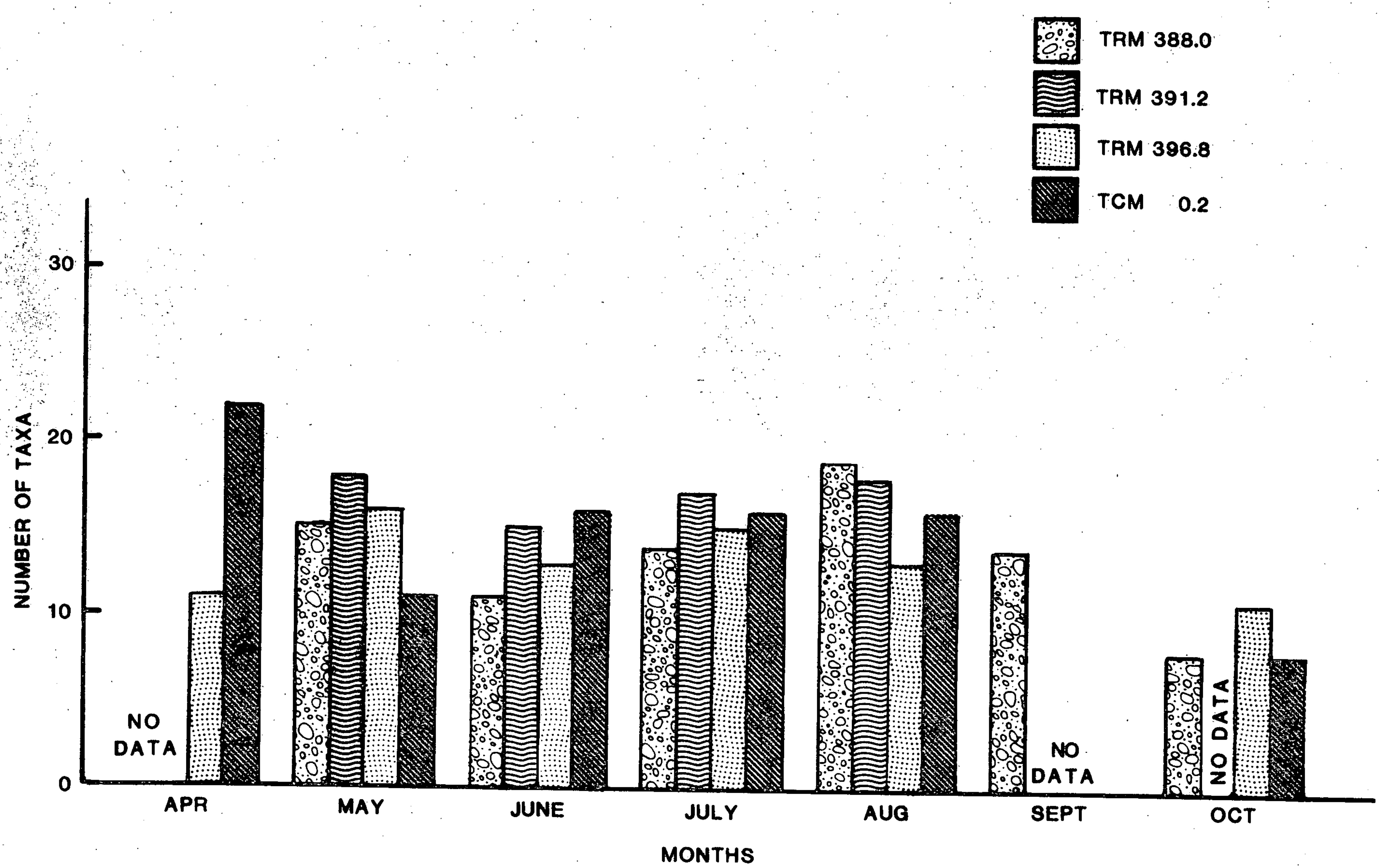


FIGURE 7.4
NUMBER OF PERIPHYTIC PHYTOPLANKTON TAXA THAT COLONIZED ARTIFICIAL SUBSTRATES IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT APRIL TO OCTOBER 1977

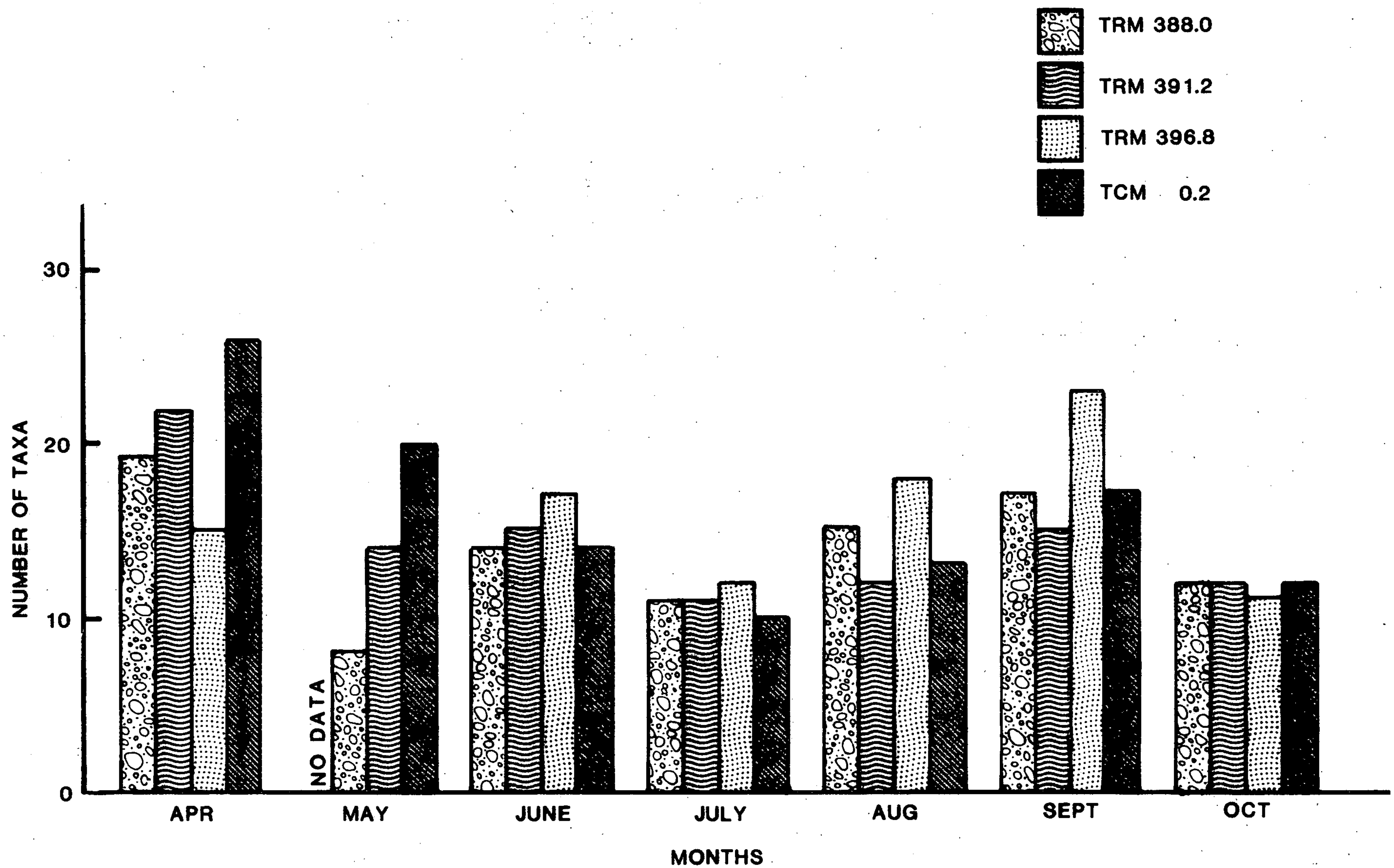


FIGURE 7.5

NUMBER OF PERIPHYTIC PHYTOPLANKTON TAXA THAT COLONIZED ARTIFICIAL SUBSTRATES IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT APRIL TO OCTOBER 1978

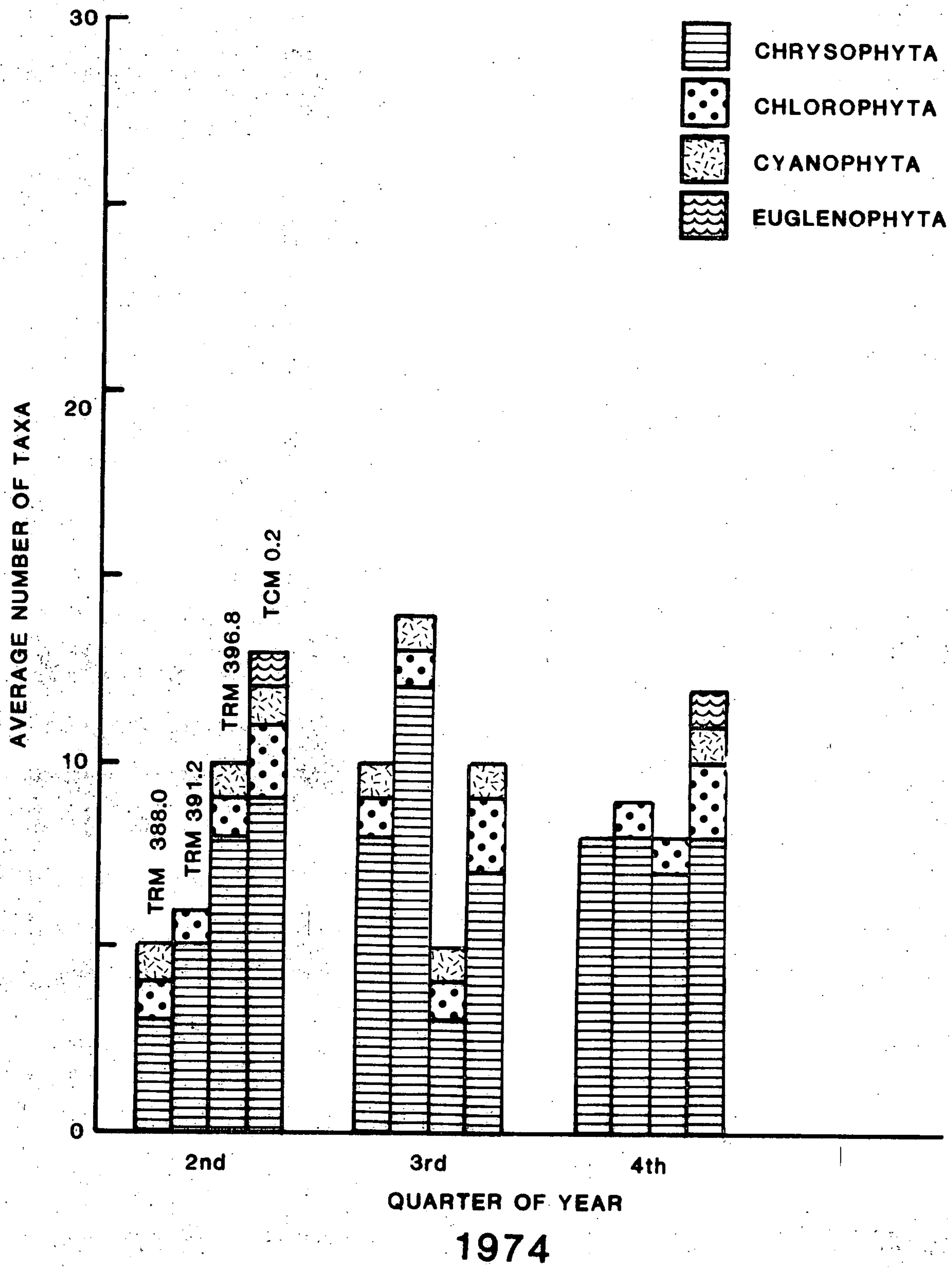


FIGURE 7.6
AVERAGE NUMBER OF PERIPHYTIC TAXA OF PHYTOPLANKTON
BY SEASON AND STATION
IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

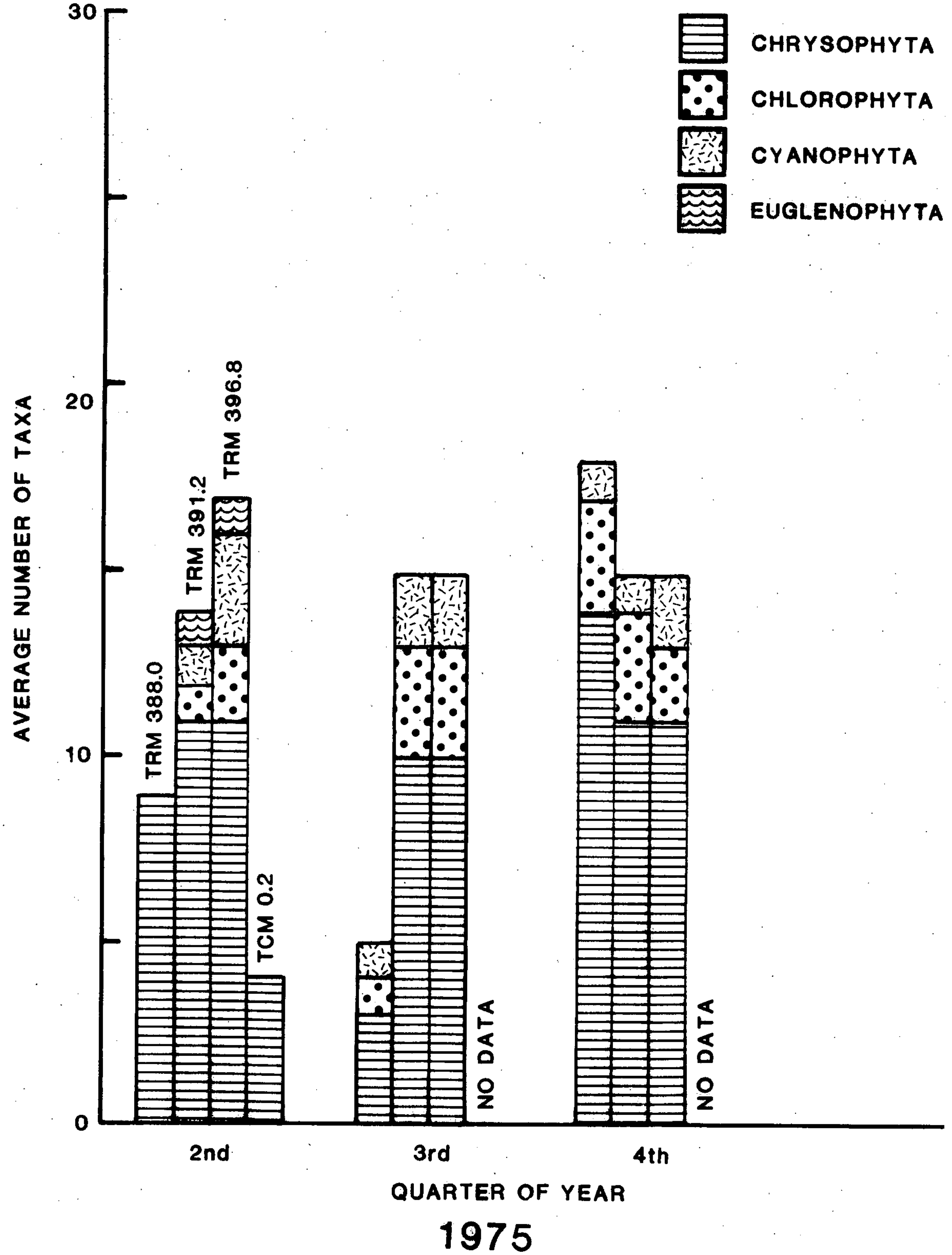


FIGURE 7.7

AVERAGE NUMBER OF PERIPHYTIC TAXA OF PHYTOPLANKTON BY SEASON AND STATION IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

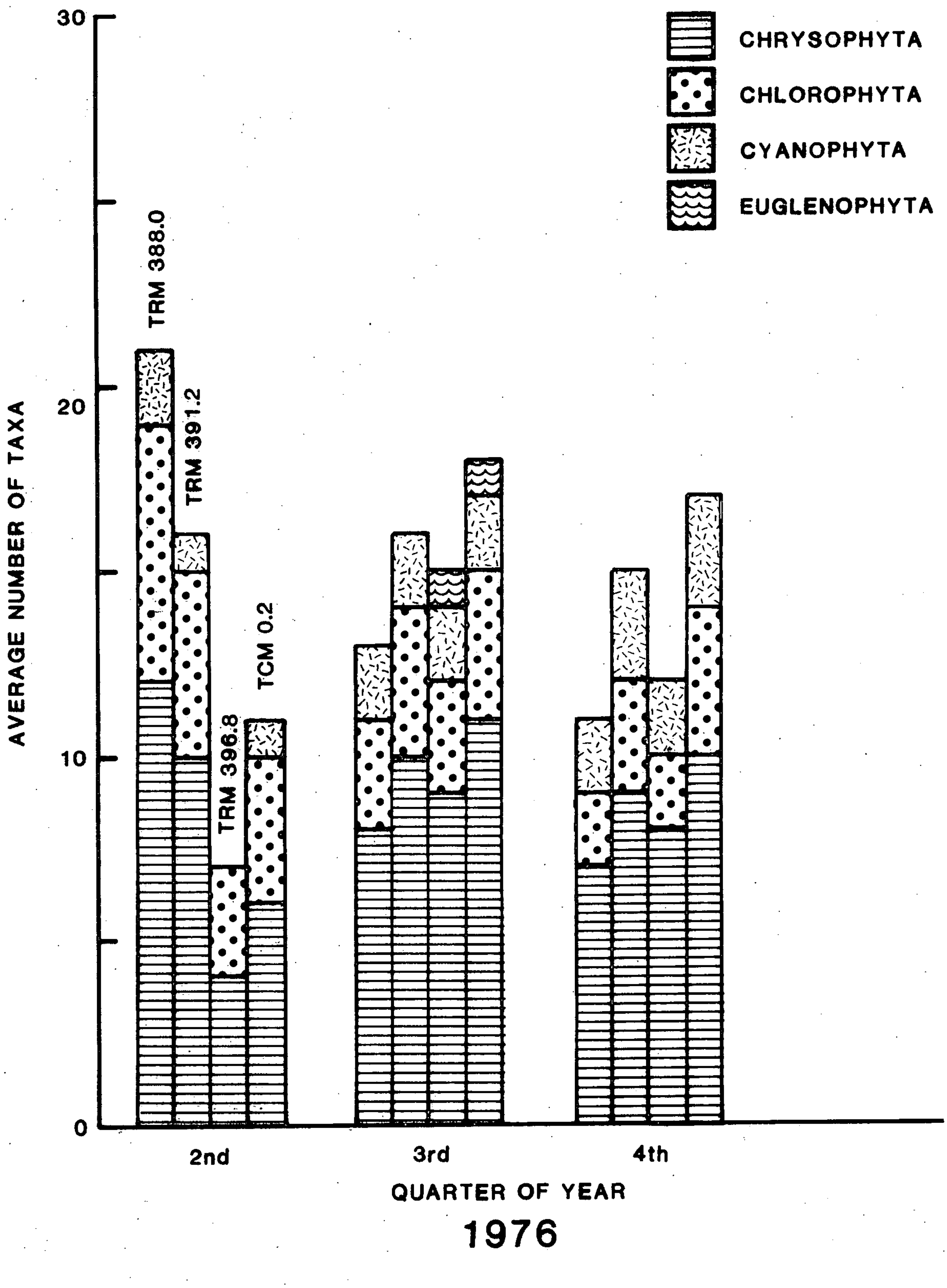


FIGURE 7.8

AVERAGE NUMBER OF PERIPHYTIC TAXA OF PHYTOPLANKTON BY SEASON AND STATION IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

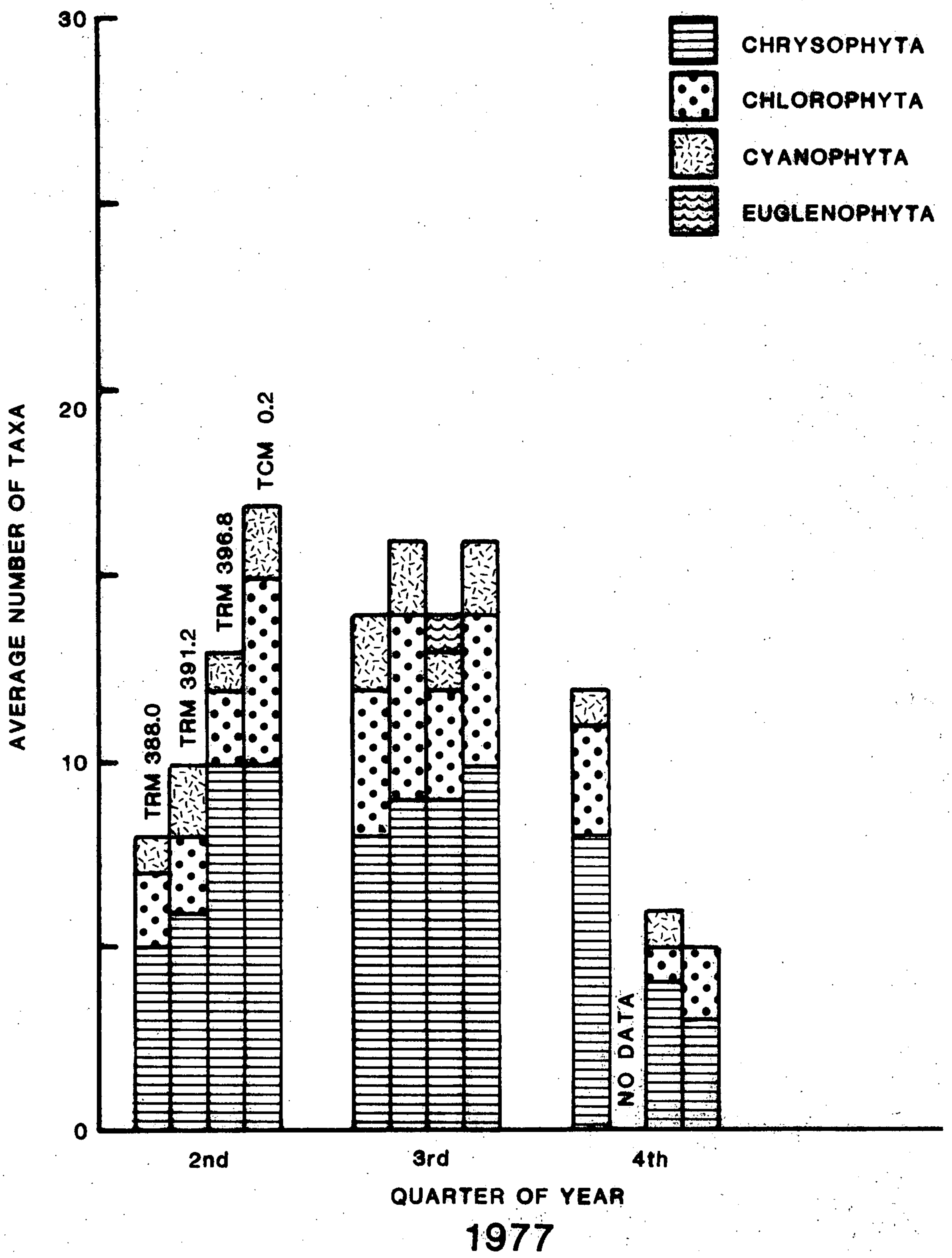


FIGURE 7.9
AVERAGE NUMBER OF PERIPHYTIC TAXA OF PHYTOPLANKTON
BY SEASON AND STATION
IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

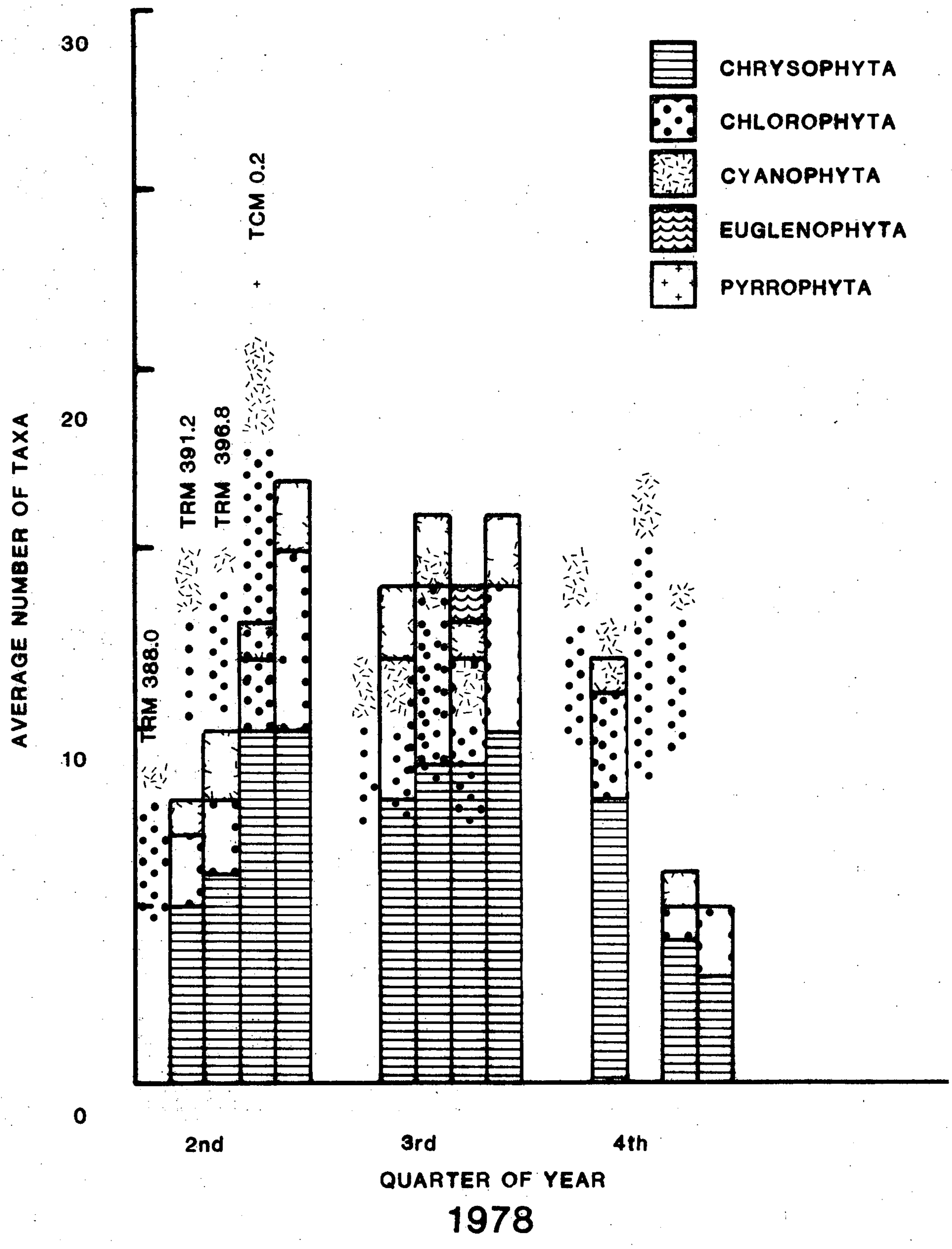


FIGURE 7.10
AVERAGE NUMBER OF PERIPHYTIC TAXA OF PHYTOPLANKTON
BY SEASON AND STATION
IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT

8.0 ZOOPLANKTON

Introduction

Zooplankters are a diverse group of microscopic and macroscopic organisms that either swim weakly or drift with the water currents. Freshwater zooplankton is represented mainly by the Phyla Rotifera and Arthropoda. Zooplankton organisms are important in the aquatic food web as secondary producers and provide a direct route for energy flow between the primary producers (phytoplankton) and the secondary consumers (fish). For these reasons, zooplankton sampling was included as part of the preoperational monitoring.

Methods and Materials

Zooplankton samples were collected monthly February through October at Town Creek mile 0.2 and three channel stations at Tennessee River mile (TRM) 388.0, 391.2, and 396.8 from 1974 through 1978. Beginning in March 1978 and continuing through October 1979, samples were collected monthly on the left overbank at TRM's 386.4, 388.4, and 391.1. Zooplankton sampling was continued at the channel station at TRM 396.8 through October 1979.

Two replicate zooplankton samples were taken by lowering a 50-cm-diameter net (80 μm mesh) equipped with a digital flowmeter and opening device to the bottom and pulling it to the surface. Samples were placed in glass sample bottles, preserved with 10 percent formalin and returned to the laboratory. Four 1 ml subsamples were taken from each magnetically stirred sample and examined microscopically at a magnification range of 30X to 50X. All specimens in each subsample were enumerated to species where practicable. The remainder of the sample was scanned for any additional species not encountered in the four subsamples.

Diversity indices ($\bar{d}$) were calculated using the following equation (Patten 1962):

$$\bar{d} = -\Sigma_1^s (n_1/n) \log_2(n_1/n)$$

where
s = number of species in unit area
n_1 = number of individuals belonging to the species
n = total number of organisms
$\bar{d}$ = diversity

Results

Zooplankton sampling yielded a total of 169 taxa collected during the six years of preoperational monitoring in the vicinity of the Bellefonte Nuclear Plant. These taxa are listed in table 8.1 and illustrated in figures 8.1 to 8.7. Rotifera was the dominant group represented by 78 taxa followed by Cladocera with 50, Copepoda with 36, and Branchiura with 1. The total number of taxa collected at each station for the entire period is summarized below.

Year	Number of Zooplankton Taxa			
	TRM 388.0	TRM 391.2	TRM 396.8	TCM 0.2
1974	69	56	60	a
1975	60	59	56	61
1976	74	66	64	93
1977	98	93	88	108
1978	87	88	91	87
	TRM 386.4	TRM 388.4	TRM 391.1	TRM 396.8
1978	104	100	89	91
1979	91	102	95	86

a. Samples not collected.

The number of taxa found at the stations varied from a maximum of 108 at TCM 0.2 in 1977 to a minimum of 56 at TRM 391.2 in 1974 and TRM 396.8 in 1975. The occurrence of individual zooplankton taxa over the monitoring period is shown in appendix J. The seasonal number of taxa are grouped by divisions and shown in figures 8.8 to 8.14. The most frequently occurring taxa included _Asplanchna_, _Bracnionus_, _Concochilus_, _Keratella_, _Polyarthra_, _Synchaeta_, _Trichocerca_, _Bosmina_, _Daphnia_, _Diaphanosoma_, _Cyclops_, _Diaptomus_, _Mesocyclops_, copepodids of Cyclopoida and Calanoida, and naupliar copepods. Because of the differences in mainstream and overbank habitat and hydrology, it is difficult to make comparisons of the zooplankton communities in the two areas.

Diversity indices ($\bar{d}$) and numbers of zooplankton taxa are shown in table 8.2. Highest $\bar{d}$ values occurred in late summer and were lowest in winter and fall. Indices varied from 3.90 at TRM 391.2 in July 1978 to 1.02 at TRM 396.8 in October 1974 at the channel stations. At TCM 0.2 the maximum index value was 4.00 in July 1977 and was lowest at 1.81 in July 1976. The maximum and minimum $\bar{d}$ values for the overbank stations were 4.29 (TRM 388.4, August 1978) and 1.74 (TRM 386.4, September 1979).

The zooplankton standing crop (number/m^3) estimates obtained during the six year monitoring program are summarized in tables K.1 to K.7 of appendix K. The highest standing crop estimate at the channel stations occurred in 1977. During the rest of the monitoring period, no consistent pattern was apparent (figures 8.15 to 8.21). Channel station standing crop ranged from 48.5 x $10^3/m^3$ at TRM 391.2 in 1978 to 2.7 x $10^3/m^3$ at TRM 388.0 in 1975. Standing crop at TCM 0.2 ranged from 89.4 x $10^3/m^3$ in 1977 to 55.9 x $10^3/m^3$ in 1978.

Zooplankton standing crop for the overbank stations are illustrated in figures 8.20 to 8.21. The standing crop ranged from 112.3 x $10^3/m^3$ at TRM 391.1 in 1978 to 13.9 x $10^3/m^3$ at TRM 386.4 in 1979. The most striking differences occurred at TRM 391.1 in August 1979 when standing crop reached 346.7 x $10^3/m^3$ while at TRM 386.4 and TRM 388.4, the values were 155.8 x $10^3/m^3$ and 23.7 x $10^3/m^3$, respectively. Densities were usually similar for any given season at the overbank stations. The greatest difference in zooplankton standing crop was the higher numbers at channel stations compared to lower numbers at overbank stations. This was expected since habitat and hydrologic conditions are more favorable on the overbanks.

The percentage composition of the zooplankton is shown in table 8.3. Rotifera was the most abundant group during 14 of the 23 sampling periods. During six sample periods, Cladocerca was the dominant group and Copepoda was the most abundant group during two periods. Taxonomic composition varied widely between stations. At channel stations, rotifers reached a high of 92.6 percent (TRM 388.0, winter 1977) and a low of 4.9 percent (TRM 396.8, fall 1974). Cladocerans ranged from 91.6 percent at TRM 396.8 in the fall of 1974 to 0.2 at TRM 391.2 in the winter of 1976. Copepods ranged from 69.3 percent at TRM 388.0 in the fall of 1975 to 2.6 percent at TRM 388.0 in the fall of 1974. At the overbank stations, rotifers ranged from 91.9 percent at TRM 386.4 in the summer of 1978 to 14.9 percent at TRM 388.4 in the fall of 1979. Cladocerans ranged from 59.8 percent at TRM 386.4 in the fall of 1978 to a minimum of 5.5 percent at TRM 391.1 in the fall of 1978. Copepods ranged from 60.3 percent at TRM 391.1 in the fall of 1979 to 6.6 percent at TRM 386.4 in the summer of 1978.

Summary

Preoperational monitoring data demonstrate fluctuations in the zooplankton community associated with seasonal factors and habitat differences. Standing crops on the overbanks were much higher than at the channel stations, which is probably related to differences in rate of water flow in each area. Zooplankton density was higher in 1977 than in other years sampled and lowest in 1975, when the mean did not exceed $2.9 \times 10^3/m^3$ at any mainstream station.

Differences in $\bar{d}$ and composition of zooplankton occurred mostly by seasons rather than between stations of similar habitat. Diversity indices were generally higher in summer and lowest in the fall and winter. The pattern of abundance or density was much more inconsistent than diversity indices. The greatest density ($289.5 \times 10^3/m^3$) of zooplankton was collected at TRM 391.2 in June 1978 and the lowest density ($0.4 \times 10^3/m^3$) at TRM 396.8 in October 1979, both of which were channel stations. Large standing crop differences between channel and overbank stations, were attributed to habitat and hydrologic conditions.

Literature Cited

Patten, B. C. 1962. "Species Diversity in Net Phytoplankton of Raritan Bay." J. Mar. Res. 21:158-163.

Table 8.1

TAXONOMIC LIST OF ZOOPLANKTON - GUNTERSVILLE RESERVOIR IN VICINITY OF BELLEFONTE NUCLEAR PLANT - 1974-1979

Branchiura
- *Arculus* sp.

Cladocera
- *Alona affinis*
- *Alona costata*
- *Alona guttata*
- *Alona intermedia*
- *Alona karau*
- *Alona quadrangularis*
- *Alona rectangula*
- *Alona* sp.
- *Alonella* sp.
- *Bosmina longirostris*
- *Bosminopsis* sp.
- *Camptocercus rectirostris*
- *Ceriodaphnia lacustris*
- *Ceriodaphnia quadrangula*
- *Ceriodaphnia reticulata*
- *Ceriodaphnia* sp.
- *Chydorus* sp.
- *Daphnia ambigua*
- *Daphnia galeata*
- *Daphnia parvula*
- *Daphnia pulex*
- *Daphnia retrocurva*
- *Daphnia rosea*
- *Daphnia* sp.
- *Diaphanosuma leuchtenbergianum*
- *Eurycercus lamellatus*
- *Eurycercus* sp.
- *Holopedium gibberum*
- *Ilyocryptus sordidus*
- *Ilyocryptus* sp.
- *Ilyocryptus spinifer*
- *Kurzia lattissima*
- *Latona setifera*
- *Leptodora kindtii*
- *Leptodora* sp.
- *Leydigia acanthocercoides*
- *Leydigia quadrangularis*
- *Macrothrix laticornis*
- *Macrothrix rosea*
- *Moina micrura*
- *Moina minuta*
- *Moina* sp.
- *Pleuroxus denticulatus*
- *Pleuroxus hamulatus*
- *Pleuroxus* sp.
- *Scapholebris kingi*
- *Sida crystallina*
- *Simocephalus serrulatus*
- *Simocephalus* sp.
- *Simocephalus vetulus*

Copepoda
- *Acanthodiaptomus denticornis*
- *Acanthodiaptomus* sp.
- *Attheyella illinoisensis*
- Calanoida
- *Canthocamptus robertcokeri*
- *Canthocamptus staphylinoides*
- Copepoda
- Cyclopoida
- *Cyclops bicuspidatus thomasi*
- *Cyclops* sp.
- *Cyclops varicans rubellus*
- *Cyclops vernalis*
- *Diaptomus birgeri*
- *Diaptomus bugalusensis*
- *Diaptomus mississippiensis*
- *Diaptomus pallidus*
- *Diaptomus reighardi*
- *Diaptomus sanguineus*
- *Diaptomus* sp.
- *Elaphoidella bidens coronata*
- *Epischura fluviatilis*
- *Ergasilus* sp.
- *Eucyclops agilis*
- *Eucyclops prionophorus*
- *Eucyclops speratus*
- Harpacticoida
- *Macrocyclops albidus*
- *Macrocyclops* sp.
- *Maraenobiotus insignipes*
- *Mesocyclops edax*
- *Mesocyclops leuckarti*
- Nauplii
- *Nitocra lacustris*
- *Osphranticum labronectum*
- *Paracyclops fimbriatus poppei*
- *Tropocyclops prasimus*

Rotifera
- *Asplanchna amphora*
- *Asplanchna brightwelli*
- *Asplanchna herricki*
- *Asplanchna priodonta*

Table 8.1 (continued)

Rotifera (continued)

- *Asplanchna* sp.
- Bdelloida
- *Beuchampiella* sp.
- *Brachionus angularis*
- *Brachionus bennini*
- *Brachionus bidentata*
- *Brachionus budapestinensis*
- *Brachinous calyciflorus*
- *Brachionus caudatus*
- *Brachionus havanaensis*
- *Brachionus nilsoni*
- *Brachionus pteriodinoides*
- *Brachionus quadridentatus*
- *Brachionus urceolaris*
- *Cephalodella* sp.
- *Collotheca pelagica*
- *Collotheca* sp.
- *Colurella* sp.
- *Conochiloides* sp.
- *Conochilus hippocrepis*
- *Conochilus unicornis*
- Contracted rotifer
- *Dipleuchlanis* sp.
- *Dissotrocha* sp.
- *Epiphanes macrourus*
- *Euchlanis* sp.
- *Filinia limnetica*
- *Filinia longiseta*
- *Filinia maior*
- *Filinia passa*
- *Filinia* sp.
- *Gastropus* sp.
- *Hexarthra intermedia*
- *Hexarthra mira*
- *Hexarthra mollis*
- *Hexarthra* sp.
- *Kellicottia bostoniensis*
- *Kellicottia longispina*
- *Keratella americana*
- *Keratella cochlearis*
- *Keratella crassa*
- *Keratella earlinae*
- *Keratella levanderi*
- *Keratella quadrata*
- *Keratella serrulata*
- *Keratella* sp.
- *Keratella valga*
- *Lecane leontina*
- *Lecane luna*
- *Lecane ohioensis*
- *Lecane* sp.
- *Lecane stokesii*
- *Lecane ungulata*
- *Lophocharis salpina*
- *Machrochaetus* sp.
- *Machrochaetus subquadratus*
- *Monostyla bulla*
- *Monostyla quadridentata*
- *Monostyla* sp.
- *Monostyla stenroosi*
- *Mytilina* sp.
- *Mytilina ventralis*
- *Notholca* sp.
- *Platyias patulus*
- *Platyias quadricornis*
- *Ploesoma hudsoni*
- *Ploesoma* sp.
- *Ploesoma truncata*
- *Polyarthra* sp.
- *Pompholyx sulcata*
- *Rotaria neptunia*
- *Rotaria* sp.
- *Synchaeta* sp.
- *Synchaeta stylata*
- *Testudinella* sp.
- *Trichocerca* sp.
- *Trichotria* sp.
- *Trichotria truncata*

Grand Total Taxa - 169

Table 8.2

DIVERSITY OF ZOOPLANKTON - CHANNEL AND OVERBANK STATIONS
BELLEFONTE NUCLEAR PLANT - 1974-1979

		1974		1975		1976		1977		1978		1979	
Month	Station	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa
February	TRM 386.4	a	a	a	a	a	a	a	a	a	a	1.90	25
	TRM 388.0	2.61	17	1.79	9	2.36	24	2.16	27	a	a	a	a
	TRM 388.4	a	a	a	a	a	a	a	a	a	a	2.69	31
	TRM 391.1	a	a	a	a	a	a	a	a	a	a	1.97	27
	TRM 391.2	2.82	20	2.19	13	2.23	28	2.45	25	a	a	a	a
	TRM 396.8	3.03	27	2.52	15	2.26	30	2.40	27	a	a	1.80	27
	TCM 0.2	a	a	2.76	a	2.64	31	2.40	43	a	a	a	a
March	TRM 386.4	a	a	a	a	a	a	a	a	2.59	33	2.46	23
	TRM 388.0	2.54	16	3.03	19	3.04	32	2.99	37	2.44	31	a	a
	TRM 388.4	a	a	a	a	a	a	a	a	2.74	31	2.34	27
	TRM 391.1	a	a	a	a	a	a	a	a	2.40	34	2.28	30
	TRM 391.2	3.03	17	2.70	18	3.16	33	3.23	34	2.56	37	a	a
	TRM 396.8	2.59	14	2.97	18	2.99	33	3.01	39	2.35	34	2.65	34
	TCM 0.2	a	a	3.30	a	2.64	31	2.69	36	2.86	35	a	a
April	TRM 386.4	a	a	a	a	a	a	a	a	2.70	42	3.19	32
	TRM 388.0	3.13	22	3.15	17	2.41	32	3.69	34	1.67	27	a	a
	TRM 388.4	a	a	a	a	a	a	a	a	2.77	32	3.31	34
	TRM 391.1	a	a	a	a	a	a	a	a	1.58	32	3.41	29
	TRM 391.2	3.18	20	3.11	17	2.29	27	3.37	27	2.00	30	a	a
	TRM 396.8	3.33	28	3.16	19	1.96	28	2.99	19	1.79	24	2.96	27
	TCM 0.2	a	a	2.76	30	3.13	36	3.37	43	3.06	39	a	a

Table 8.2 (continued)

		1974		1975		1976		1977		1978		1979	
Month	Station	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa
May	TRM 386.4	a	a	a	a	a	a	a	a	2.61	39	3.67	41
	TRM 388.0	2.26	37	3.29	27	3.27	41	2.56	40	3.52	37	a	a
	TRM 388.4	a	a	a	a	a	a	a	a	2.93	32	3.46	40
	TRM 391.1	a	a	a	a	a	a	a	a	2.41	28	3.19	40
	TRM 391.2	2.17	35	3.41	29	3.53	36	3.67	41	3.32	35	a	a
	TRM 396.8	2.42	30	3.12	26	3.51	39	2.48	30	3.41	30	2.32	34
	TCM 0.2	a	a	3.30	33	3.64	49	2.41	44	2.57	38	a	a
June	TRM 386.4	a	a	a	a	a	a	a	a	2.51	38	3.65	42
	TRM 388.0	2.97	27	2.84	20	3.29	40	2.91	39	3.41	35	a	a
	TRM 388.4	a	a	a	a	a	a	a	a	2.83	30	3.45	42
	TRM 391.1	a	a	a	a	a	a	a	a	3.80	36	3.65	41
	TRM 391.2	3.46	28	2.91	22	3.26	41	2.79	37	2.37	31	a	a
	TRM 396.8	3.21	28	3.31	25	3.46	40	3.49	37	3.23	32	2.69	36
	TCM 0.2	a	a	3.11	26	3.72	63	2.92	39	3.26	39	a	a
July	TRM 386.4	a	a	a	a	a	a	a	a	3.96	47	3.26	41
	TRM 388.0	3.35	22	2.29	27	3.35	33	3.15	40	3.86	36	a	a
	TRM 388.4	a	a	a	a	a	a	a	a	3.39	38	3.09	44
	TRM 391.1	a	a	a	a	a	a	a	a	3.26	31	3.20	34
	TRM 391.2	3.71	24	2.70	26	3.12	36	3.63	44	3.90	39	a	a
	TRM 396.8	2.99	19	1.96	21	2.94	35	3.88	40	3.60	37	2.84	31
	TCM 0.2	a	a	3.16	34	1.81	44	4.00	45	3.96	47	a	a

Table 8.2 (continued)

Month	Station	1974		1975		1976		1977		1978		1979	
		$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa	$\bar{d}$	Number of taxa
August	TRM 386.4	a	a	a	a	a	a	a	a	3.26	38	2.99	41
	TRM 388.0	2.00	20	1.40	22	3.14	29	2.80	45	2.58	44	a	a
	TRM 388.4	a	a	a	a	a	a	a	a	4.29	48	3.65	38
	TRM 391.1	a	a	a	a	a	a	a	a	2.99	41	2.55	29
	TRM 391.2	1.90	17	3.23	32	2.93	31	2.20	45	3.44	45	a	a
	TRM 396.8	1.77	16	2.27	26	3.02	18	2.19	35	3.53	41	3.19	37
	TCM 0.2	a	a	3.34	31	2.77	44	3.45	44	3.26	38	a	a
September	TRM 386.4	a	a	a	a	a	a	a	a	2.32	36	1.74	21
	TRM 388.0	2.34	22	3.46	25	0.96	29	3.58	46	2.01	34	a	a
	TRM 388.4	a	a	a	a	a	a	a	a	2.17	25	2.59	34
	TRM 391.1	a	a	a	a	a	a	a	a	3.41	36	2.06	37
	TRM 391.2	1.80	16	2.89	25	1.96	30	3.75	50	3.29	37	a	a
	TRM 396.8	1.18	19	2.98	20	0.81	19	3.23	32	2.52	27	2.00	32
	TCM 0.2	a	a	3.49	22	2.32	41	3.42	42	2.17	25	a	a
October	TRM 386.4	a	a	a	a	a	a	a	a	3.77	41	3.18	29
	TRM 388.0	1.98	23	2.25	26	2.94	20	2.99	22	2.49	31	a	a
	TRM 388.4	a	a	a	a	a	a	a	a	2.74	41	2.97	35
	TRM 391.1	a	a	a	a	a	a	a	a	2.23	44	2.45	35
	TRM 391.2	1.75	16	2.35	23	3.04	22	2.97	23	2.37	35	a	a
	TRM 396.8	1.02	14	2.46	17	3.04	24	2.72	22	2.52	34	2.53	27
	TCM 0.2	a	a	2.83	31	2.86	29	2.29	41	3.20	39	a	a

a. Samples not collected.

Table 8.3

ZOOPLANKTON SEASONAL PERCENTAGE COMPOSITION - GUNTERSVILLE RESERVOIR
IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT
1974-1979

Year	Season	Station	Cladocera	Copepoda	Rofifera
1974	Winter	TRM 388.0	7.2	42.8	50.1
		TRM 391.2	3.0	43.1	53.8
		TRM 396.8	5.9	46.7	47.3
		TCM 0.2	-	-	-
	Spring	TRM 388.0	33.2	29.8	37.1
		TRM 391.2	24.6	29.8	45.5
		TRM 396.8	22.0	32.4	45.5
		TCM 0.2	-	-	-
	Summer	TRM 388.0	56.1	8.6	35.3
		TRM 391.2	50.5	7.9	41.6
		TRM 396.8	64.2	13.6	22.1
		TCM 0.2	-	-	-
	Fall	TRM 388.0	71.8	2.6	25.8
		TRM 391.2	79.5	3.3	17.2
		TRM 396.8	91.6	3.5	4.9
		TCM 0.2	-	-	-
1975	Winter	TRM 388.0	8.7	82.7	8.6
		TRM 391.2	6.5	69.3	23.9
		TRM 396.8	9.3	66.9	23.8
		TCM 0.2			
	Spring	TRM 388.0	13.3	31.6	55.1
		TRM 391.2	10.2	33.0	56.7
		TRM 396.8	20.6	38.0	41.3
		TCM 0.2	9.4	10.2	80.5
	Summer	TRM 388.0	65.3	15.3	19.1
		TRM 391.2	35.0	15.3	49.6
		TRM 396.8	52.9	12.5	34.6
		TCM 0.2	25.5	17.8	56.7
	Fall	TRM 388.0	6.5	69.3	23.9
		TRM 391.2	68.3	6.8	25
		TRM 396.8	59.5	21.4	19.3
		TCM 0.2	21.0	22.6	56.4

Table 8.3 (continued)

Year	Season	Station	Cladocera	Copepoda	Rofifera
1976	Winter	TRM 388.0	1.0	9.1	89.9
		TRM 391.2	0.2	9.0	90.8
		TRM 396.8	1.3	8.3	90.5
		TCM 0.2	-	14.5	79.3
	Spring	TRM 388.0	24.6	17.2	58.3
		TRM 391.2	27.8	17.6	54.6
		TRM 396.8	27.8	23.2	49.0
		TCM 0.2	10.5	31.6	58.0
	Summer	TRM 388.0	36.8	21.9	41.3
		TRM 391.2	43.1	22.5	34.4
		TRM 396.8	27.8	23.2	49.0
		TCM 0.2	7.2	38.7	54.1
	Fall	TRM 388.0	64.1	14.7	24.3
		TRM 391.2	49.3	14.0	33.8
		TRM 396.8	66.5	9.3	24.2
		TCM 0.2	34.7	20.8	44.6
1977	Winter	TRM 388.0	0.4	6.9	92.6
		TRM 391.2	0.8	10.9	88.2
		TRM 396.8	0.8	30.4	68.8
		TCM 0.2	0.6	8.3	91.0
	Spring	TRM 388.0	27.5	19.1	53.4
		TRM 391.2	17.2	15.5	67.3
		TRM 396.8	30.5	16.2	53.3
		TCM 0.2	3.9	26.6	69.5
	Summer	TRM 388.0	40.3	24.3	35.5
		TRM 391.2	38.0	34.6	27.3
		TRM 396.8	43.6	24.0	59.3
		TCM 0.2	23.3	17.4	32.4
	Fall	TRM 388.0	17.6	34.0	48.4
		TRM 391.2	27.1	34.8	38.2
		TRM 396.8	41.9	25.1	57.1
		TCM 0.2	3.4	32.3	64.4

Table 8.3 (continued)

Year	Season	Station	Cladocera	Copepoda	Rofifera
1978	Winter	TRM 388.0	a	a	a
		TRM 391.2	a	a	a
		TRM 396.8	a	a	a
		TCM 0.2	a	a	a
	Spring	TRM 388.0	29.0	25.3	45.7
		TRM 391.2	27.0	28.7	44.4
		TRM 396.8	29.8	30.7	39.4
		TCM 0.2	10.6	28.6	60.8
		TRM 386.4	11.3	27.6	61.1
		TRM 388.4	7.5	32.3	57.3
		TRM 391.1	11.0	42.7	46.2
	Summer	TRM 388.0	32.6	18.7	48.7
		TRM 391.2	15.6	12.3	72.2
		TRM 396.8	26.2	16.8	57.0
		TCM 0.2	4.2	20.9	74.9
		TRM 386.4	1.5	6.6	91.9
		TRM 388.4	8.7	11.1	80.3
		TRM 391.1	6.3	9.4	84.3
	Fall	TRM 388.0	63.5	20.2	16.4
		TRM 391.2	53.5	22.3	24.3
		TRM 396.8	66.7	20.7	12.7
		TCM 0.2	55.6	25.9	18.6
		TRM 386.4	59.8	21.3	19.0
		TRM 388.4	29.2	40.0	30.8
		TRM 391.1	5.5	9.0	85.6
1979	Winter	TRM 396.8	1.5	17.3	81.2
		TRM 386.4	2.0	23.5	74.4
		TRM 388.4	16.4	34.1	49.5
		TRM 391.1	14.7	54.0	31.3
	Spring	TRM 396.8	22.5	34.8	42.7
		TRM 386.4	11.0	19.4	69.6
		TRM 388.4	16.1	31.3	52.7
		TRM 391.1	14.0	33.5	51.5
	Summer	TRM 396.8	39.1	17.2	43.7
		TRM 386.4	21.7	10.6	67.7
		TRM 388.4	26.3	14.4	59.4
		TRM 391.1	6.0	9.7	84.2
	Fall	TRM 396.8	39.9	27.7	12.5
		TRM 386.4	55.6	15.9	28.6
		TRM 388.4	36.8	48.3	14.9
		TRM 391.1	11.1	60.3	28.6

a. Samples not collected.

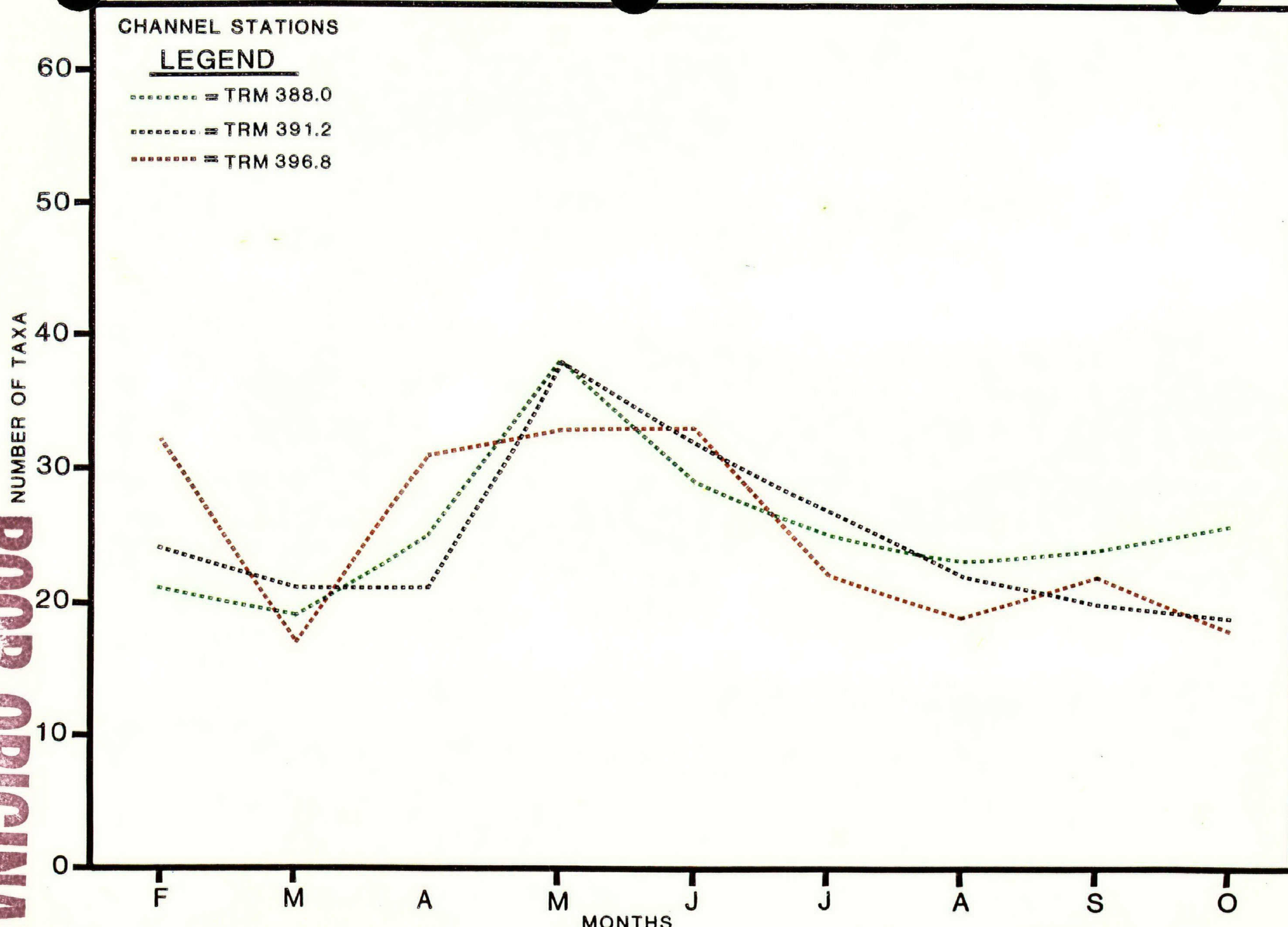


FIGURE 8.1 TOTAL NUMBER OF ZOOPLANKTON TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR SITE FROM FEBRUARY TO OCTOBER 1974

POOR ORIGINAL

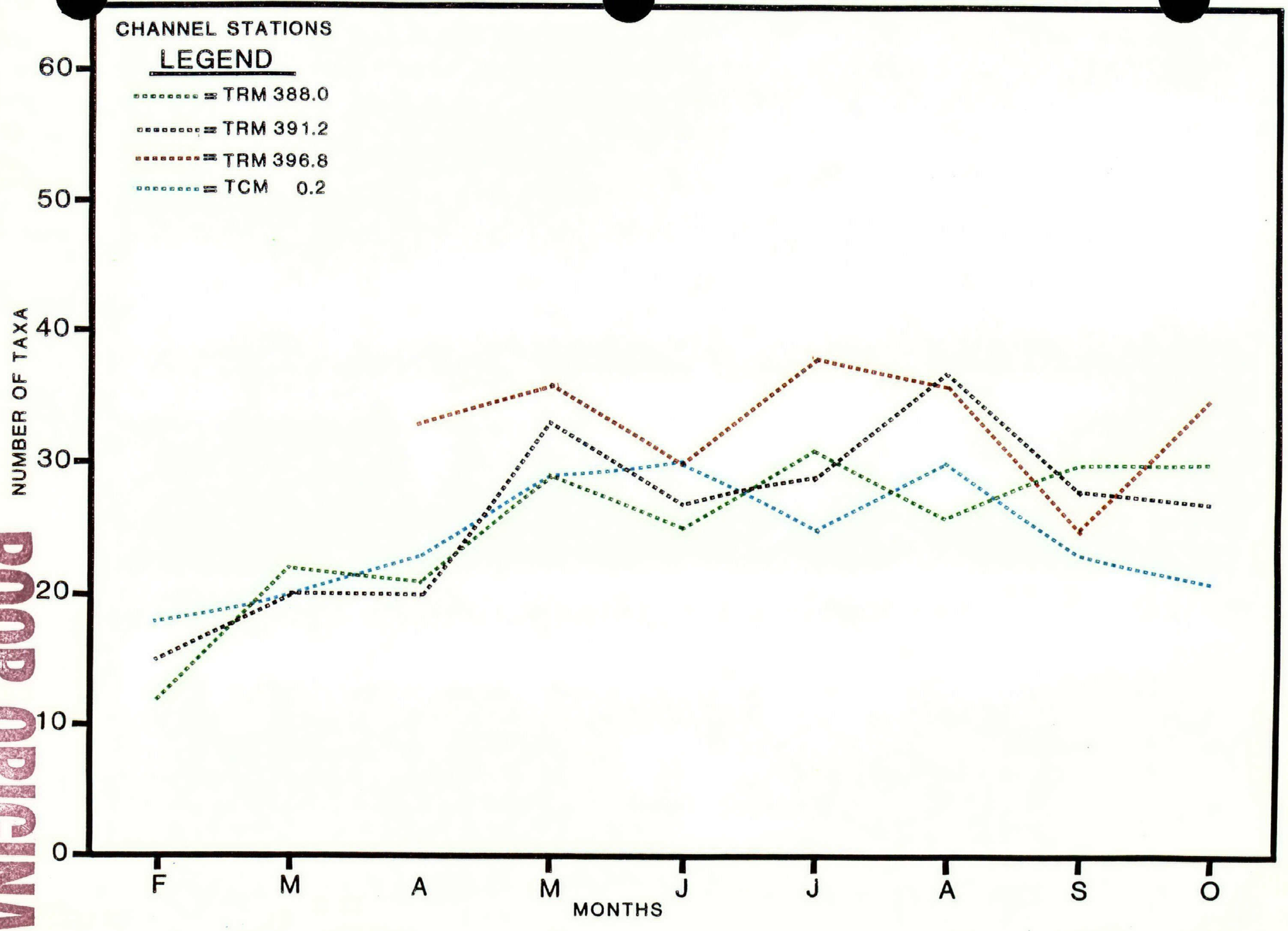
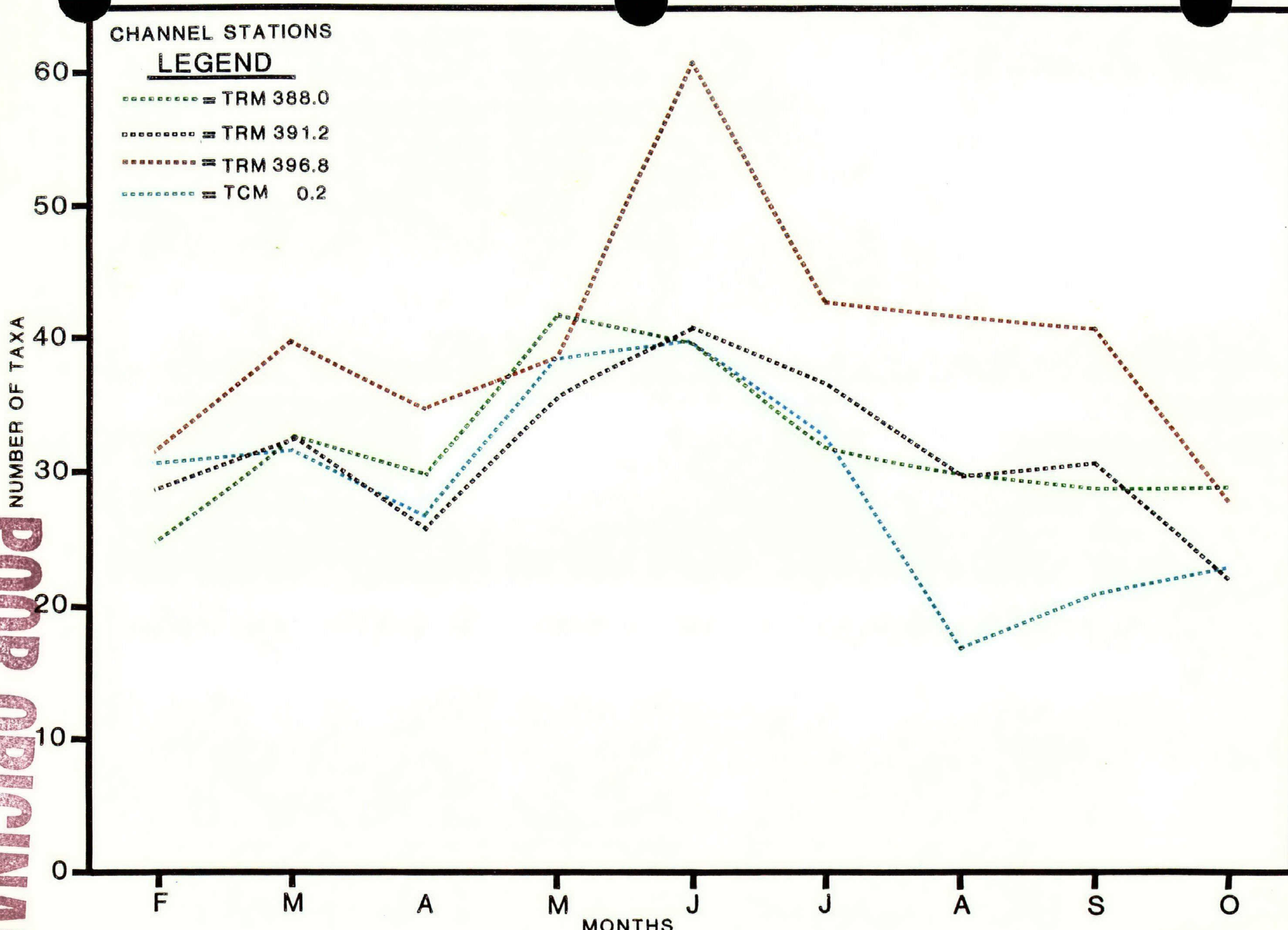


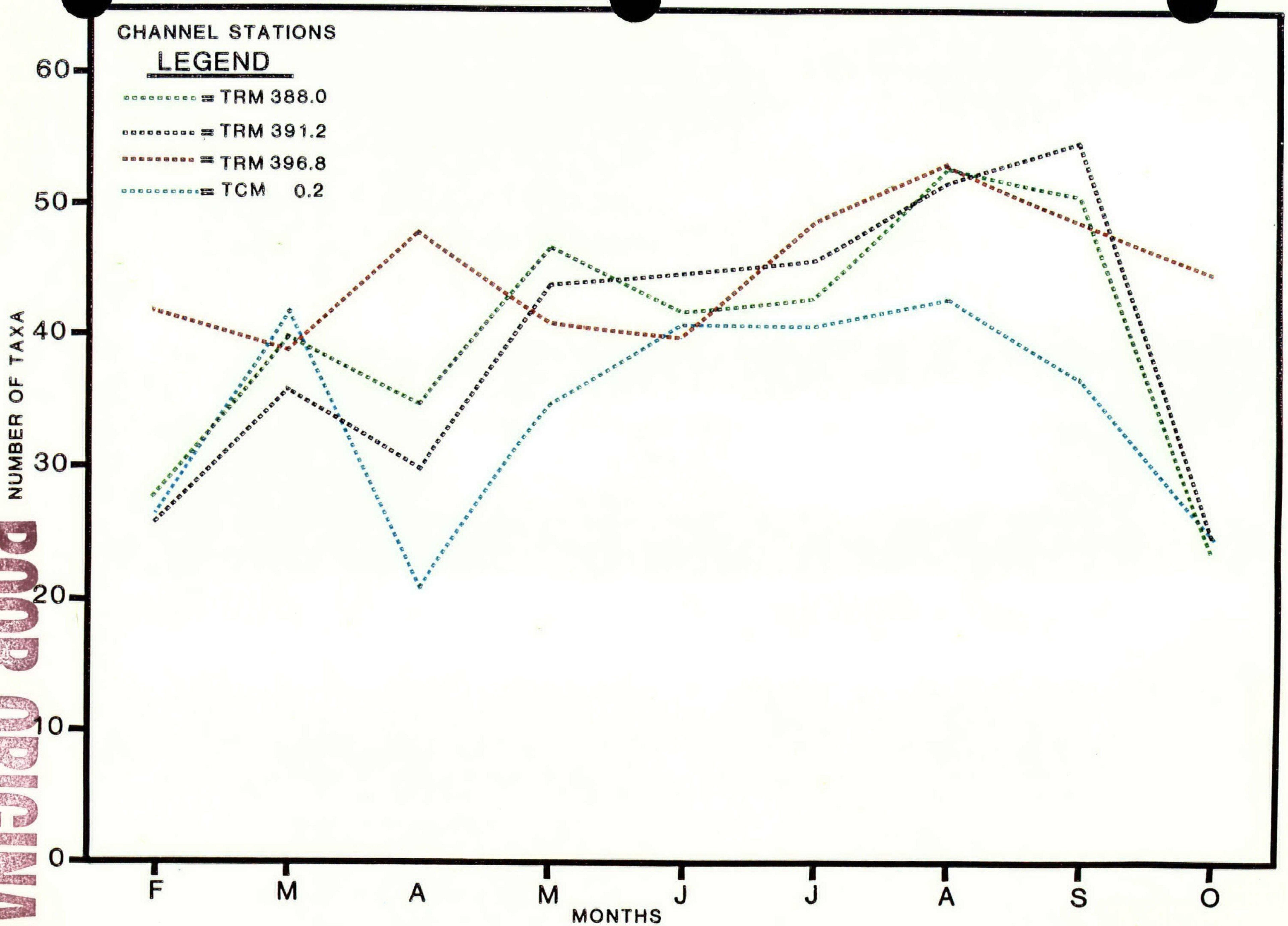
FIGURE 8.2 TOTAL NUMBER OF ZOOPLANKTON TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT SITE FROM FEBRUARY TO OCTOBER 1975

POOR ORIGINAL



POOR ORIGINAL

FIGURE 8.3 TOTAL NUMBER OF ZOOPLANKTON TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFFONTE NUCLEAR PLANT SITE FROM FEBRUARY TO OCTOBER 1976



POOR ORIGINAL

FIGURE 8.4 TOTAL NUMBER OF ZOOPLANKTON TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT SITE FROM FEBRUARY TO OCTOBER 1977

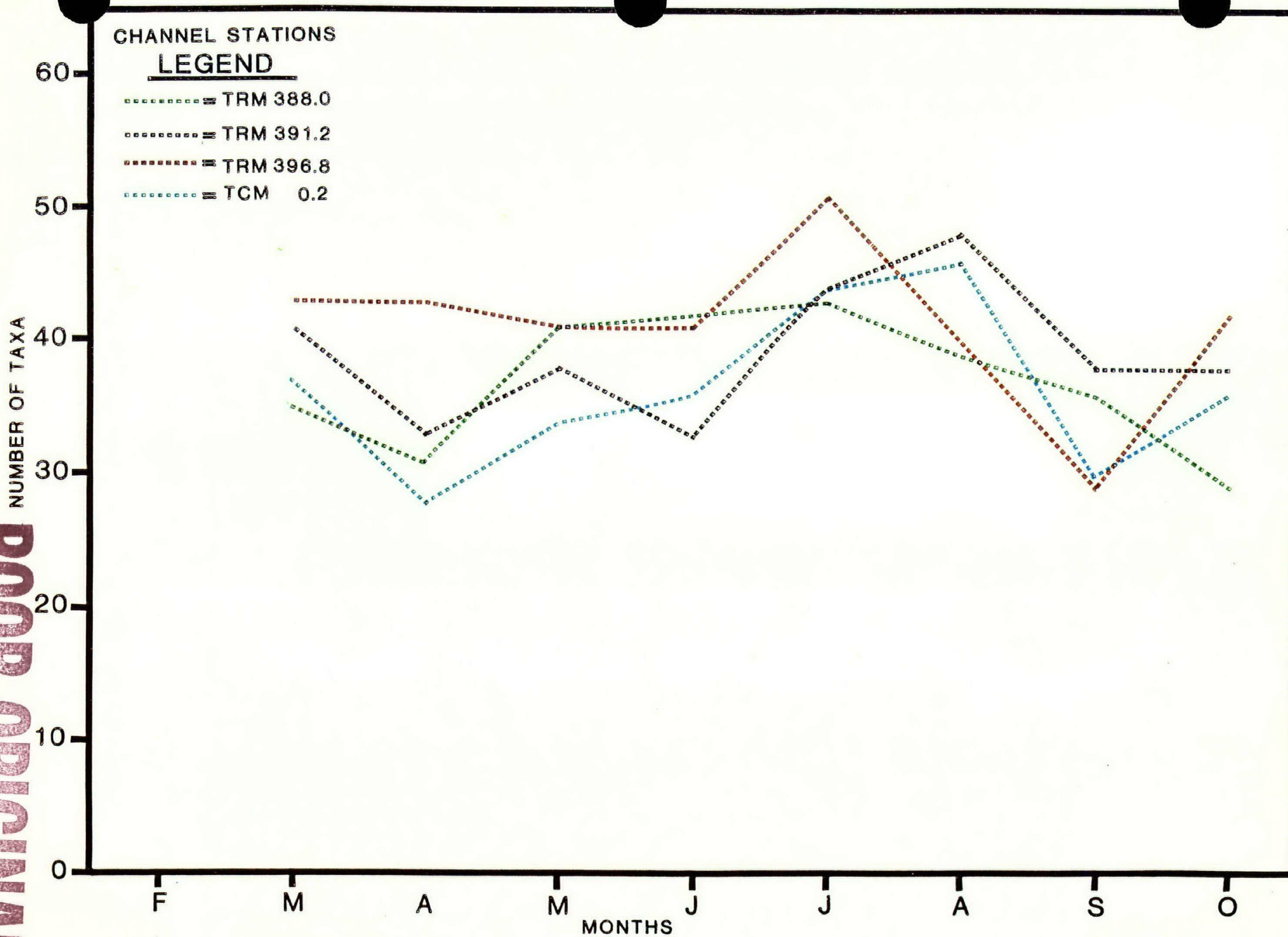


FIGURE 8.5 TOTAL NUMBER OF ZOOPLANKTON TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT SITE FROM FEBRUARY TO OCTOBER 1978

POOR ORIGINAL

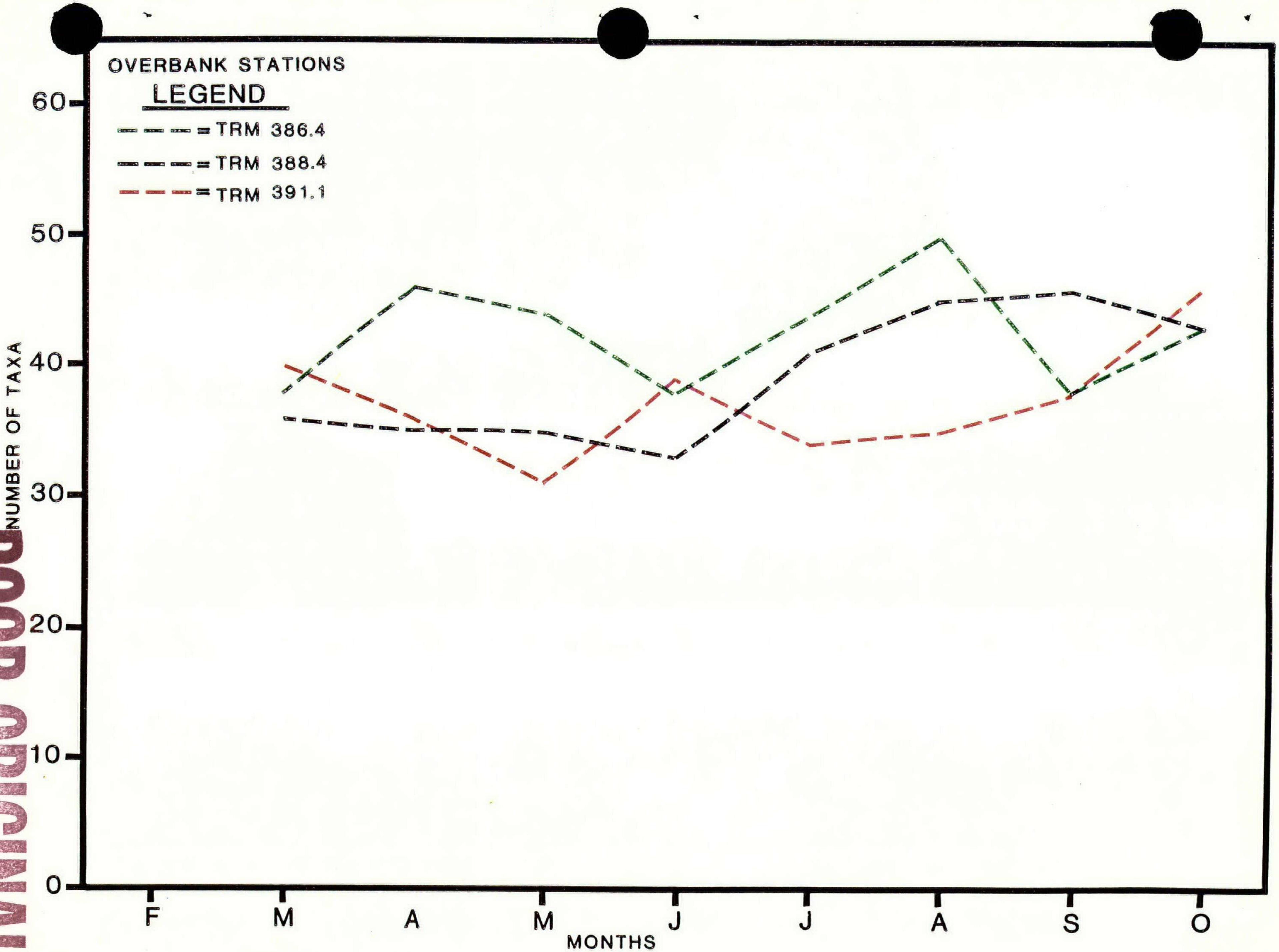


FIGURE 8.6 TOTAL NUMBER OF ZOOPLANKTON TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT SITE FROM FEBRUARY TO OCTOBER 1978

POOR ORIGINAL

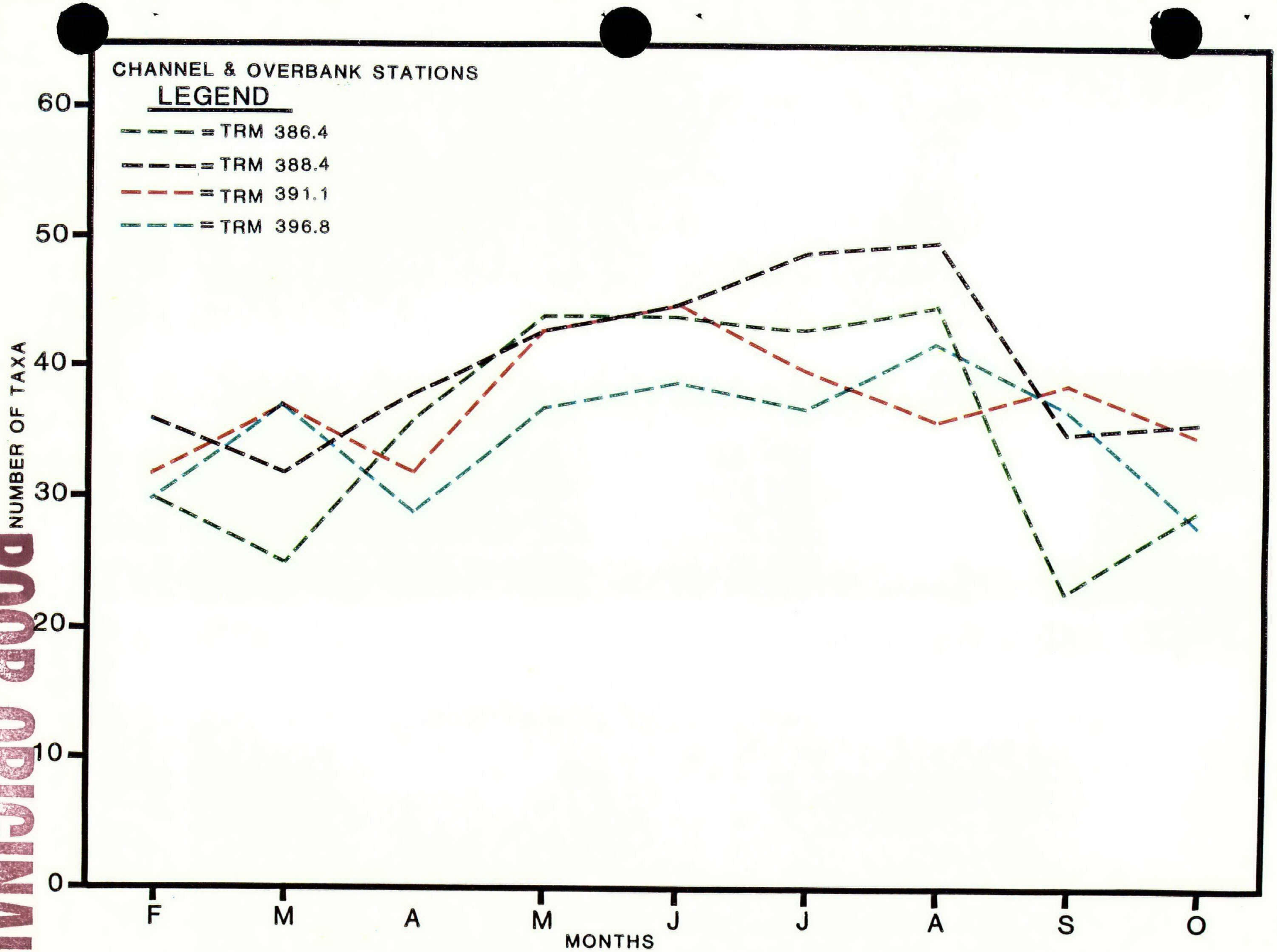


FIGURE 8.7 TOTAL NUMBER OF ZOOPLANKTON TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT SITE FROM FEBRUARY TO OCTOBER 1979

POOR ORIGINAL

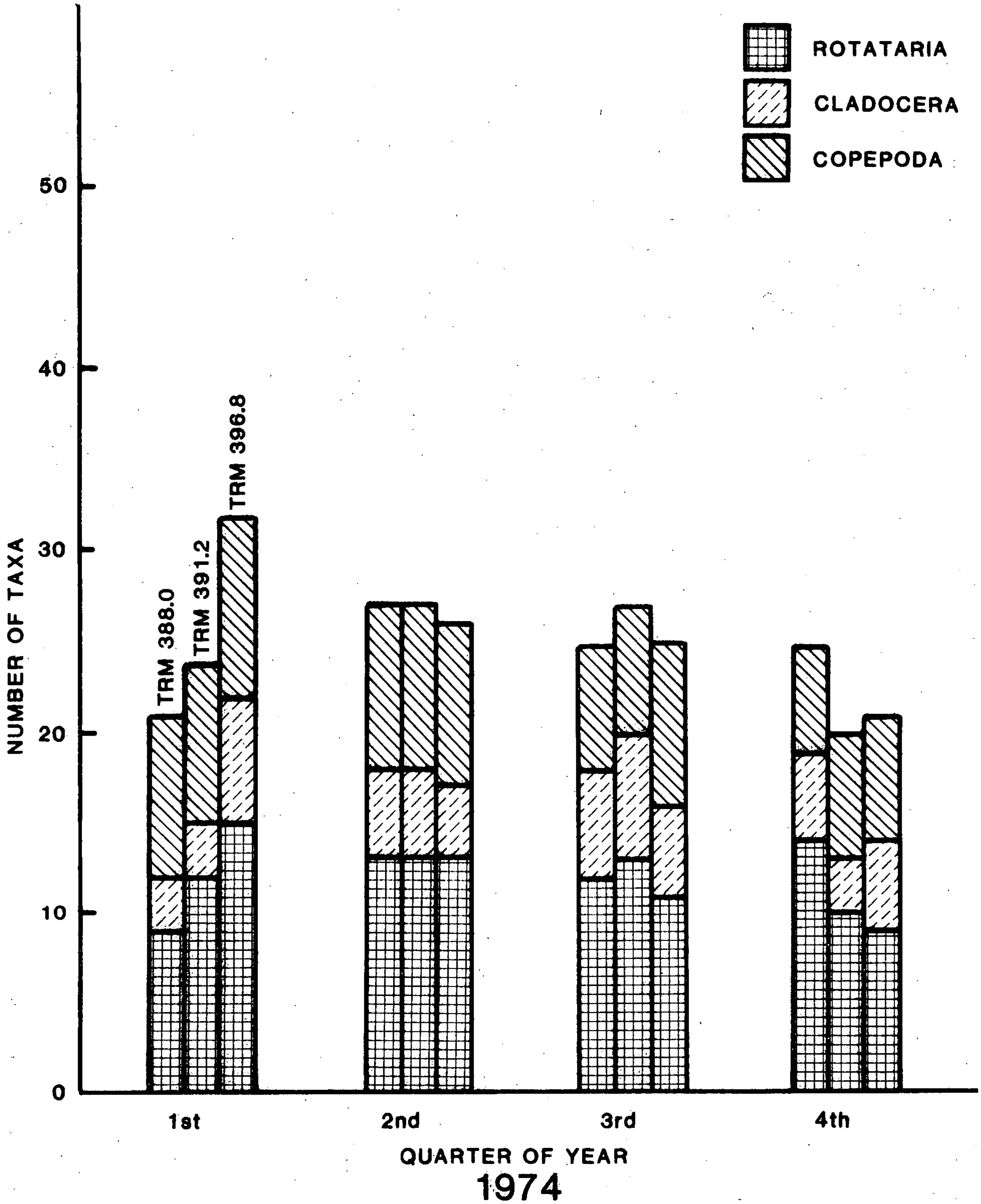


FIGURE 8.8

NUMBER OF TAXA IN EACH ZOOPLANKTON DIVISION BY SEASON AND STATION

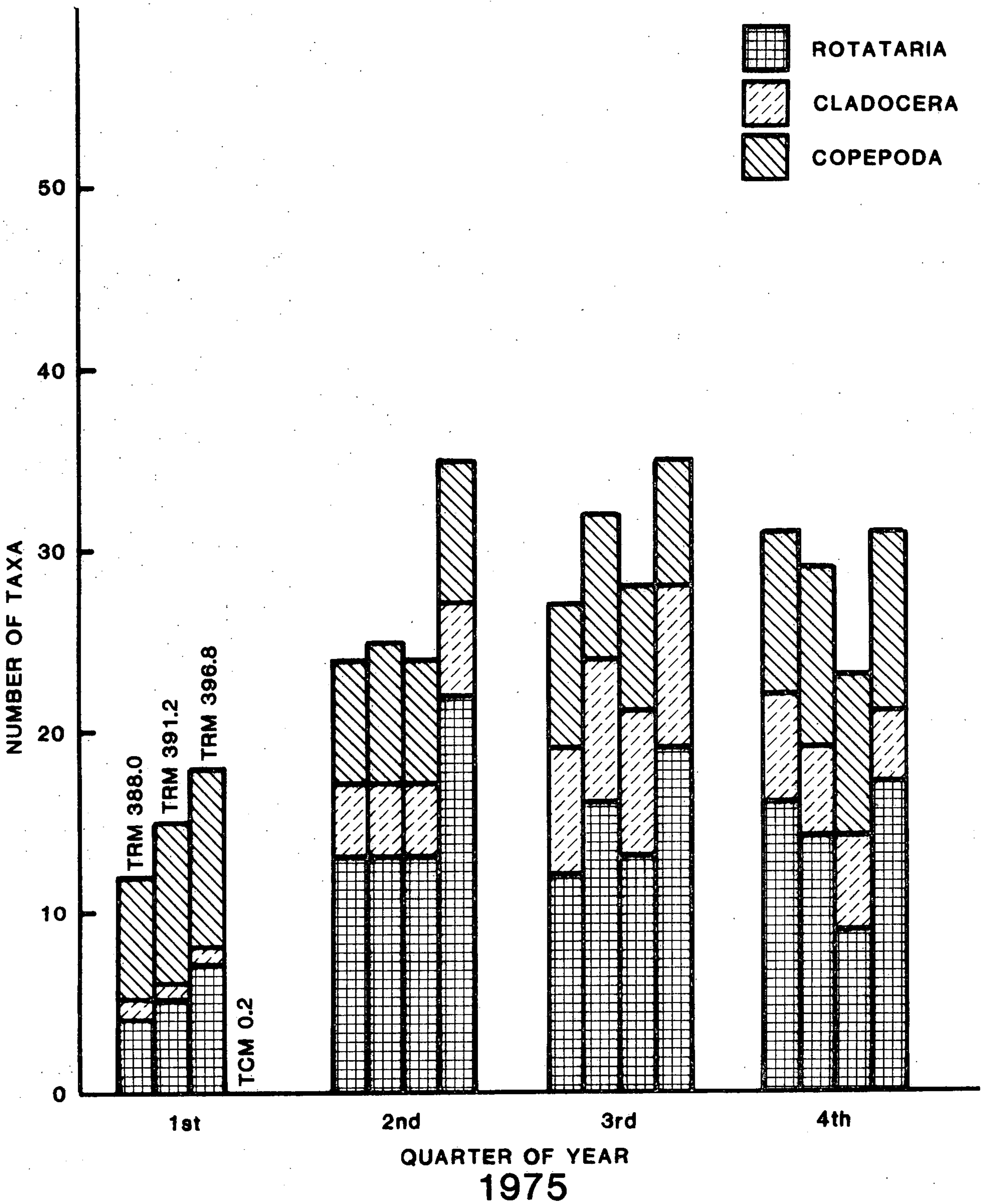


FIGURE 8.9

NUMBER OF TAXA IN EACH ZOOPLANKTON DIVISION BY SEASON AND STATION

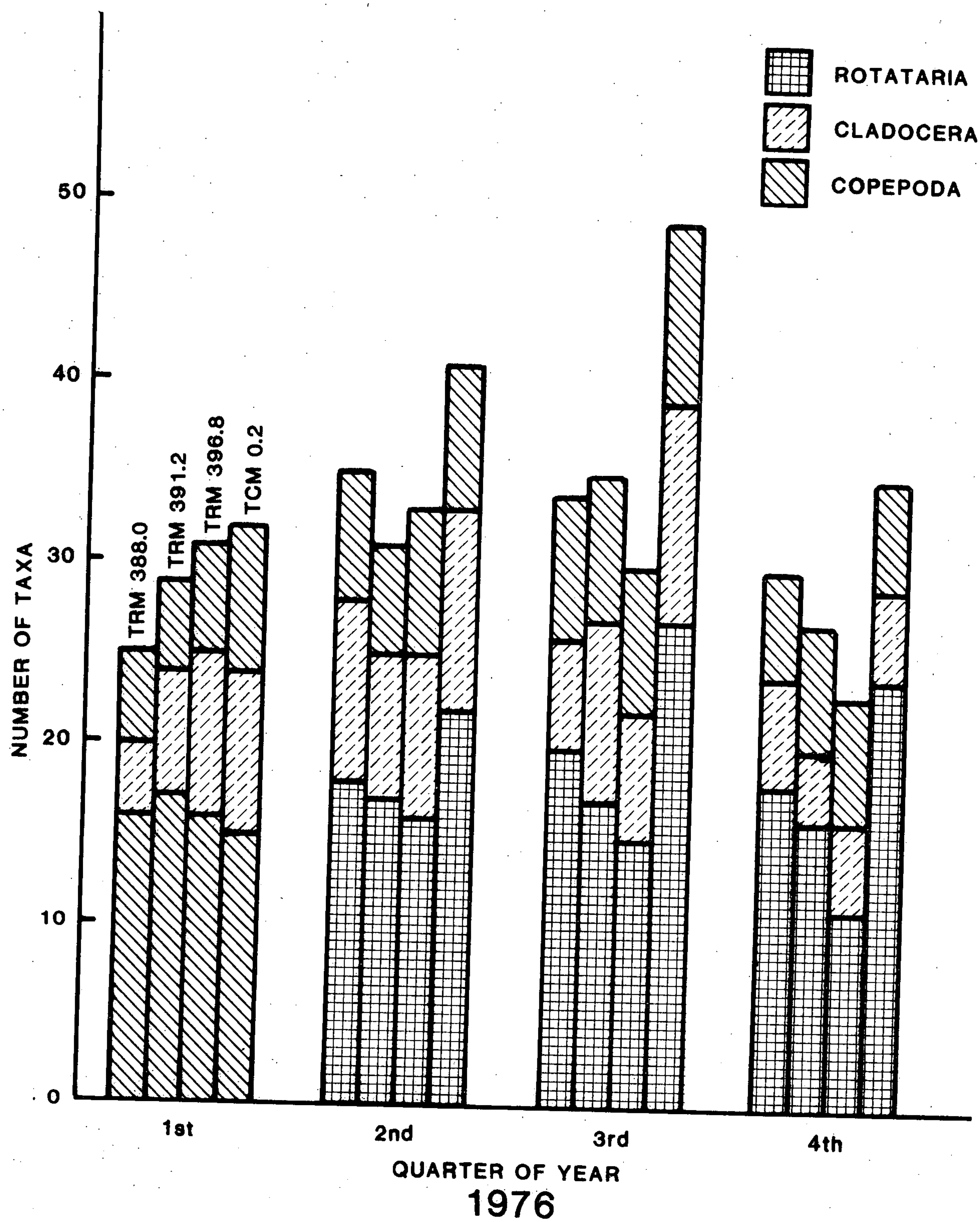


FIGURE 8.10
NUMBER OF TAXA IN EACH ZOOPLANKTON DIVISION BY SEASON AND STATION

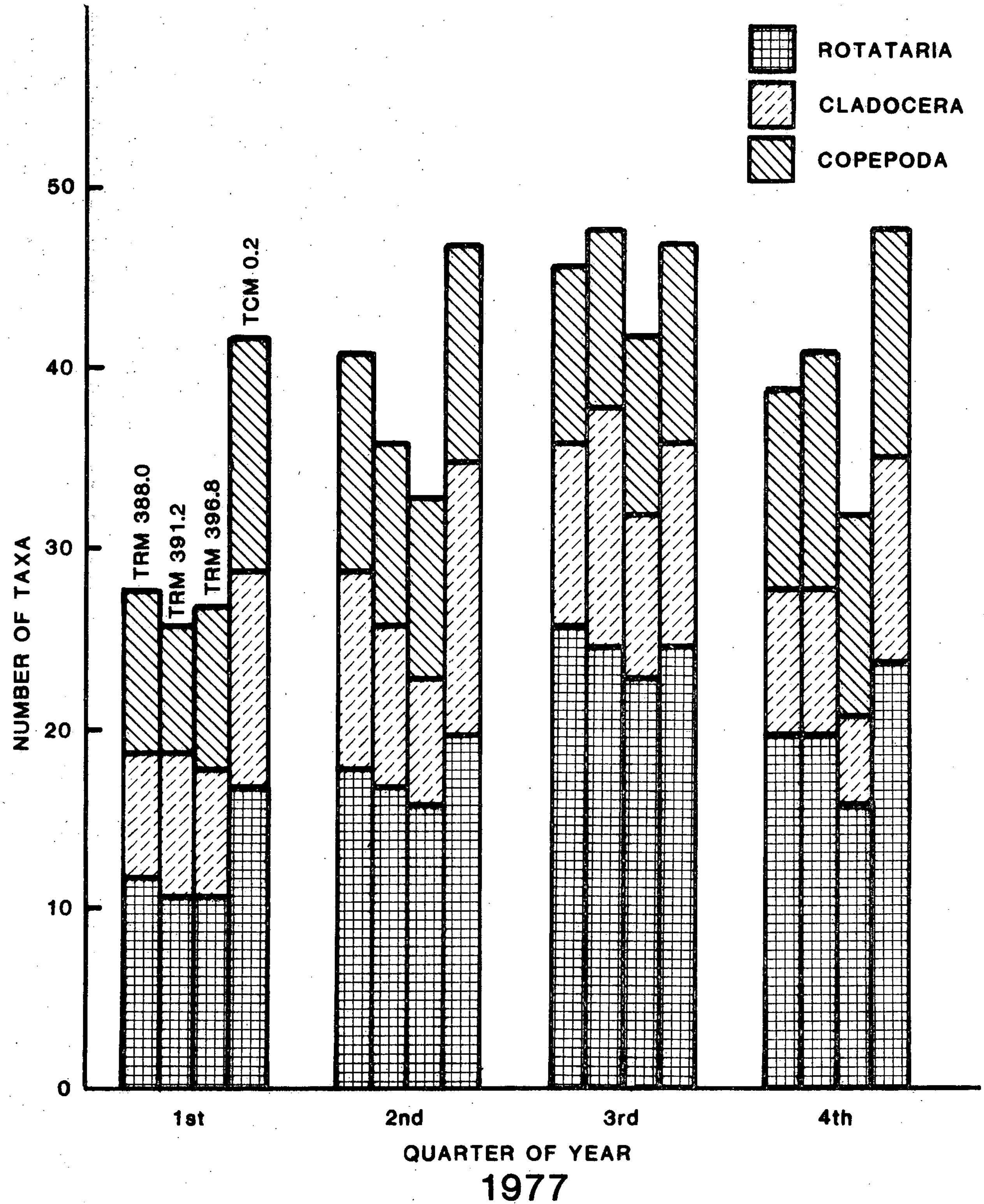


FIGURE 8.11

NUMBER OF TAXA IN EACH ZOOPLANKTON DIVISION BY SEASON AHD STATION

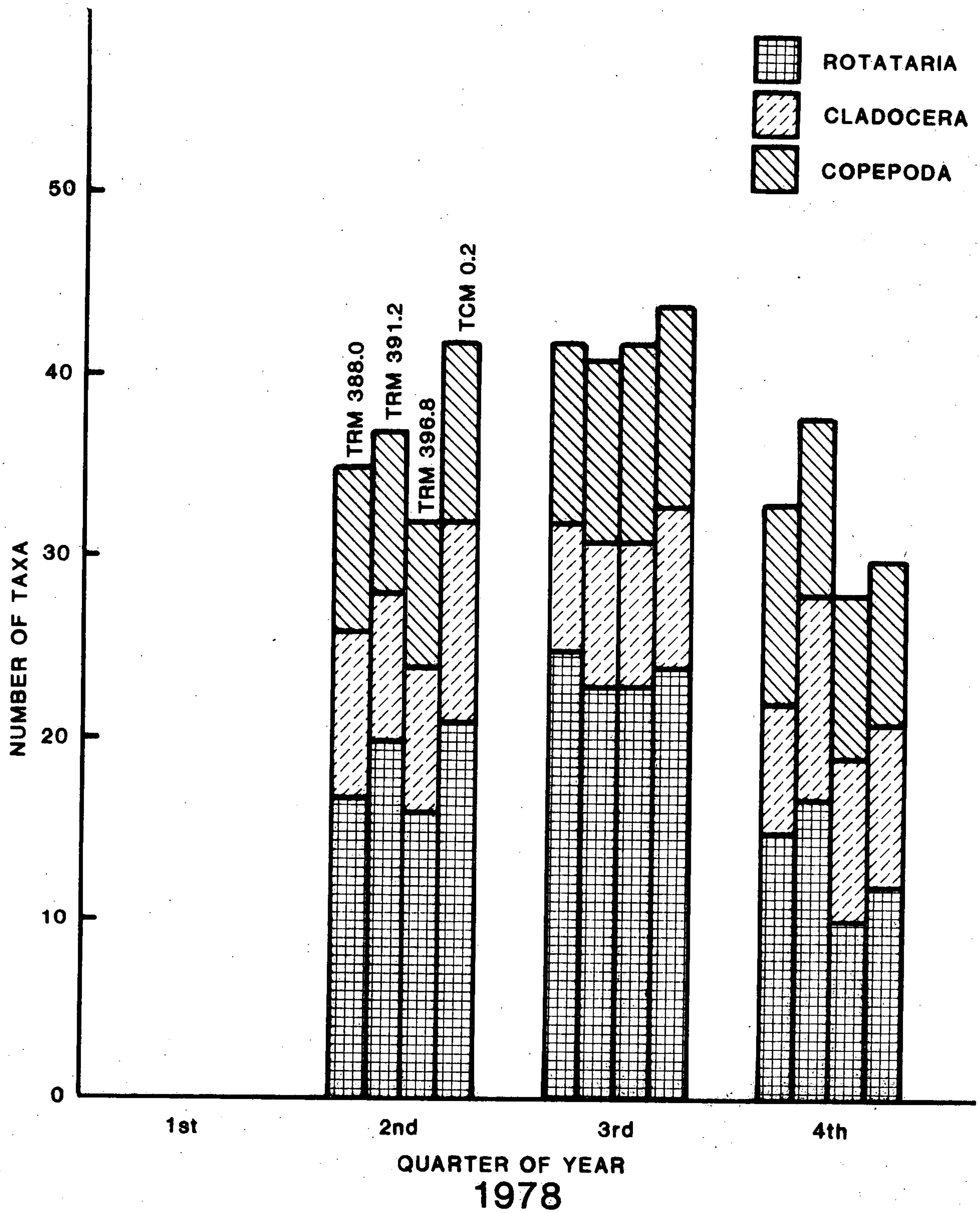


FIGURE 8.12
NUMBER OF TAXA IN EACH ZOOPLANKTON DIVISION BY SEASON AND STATION

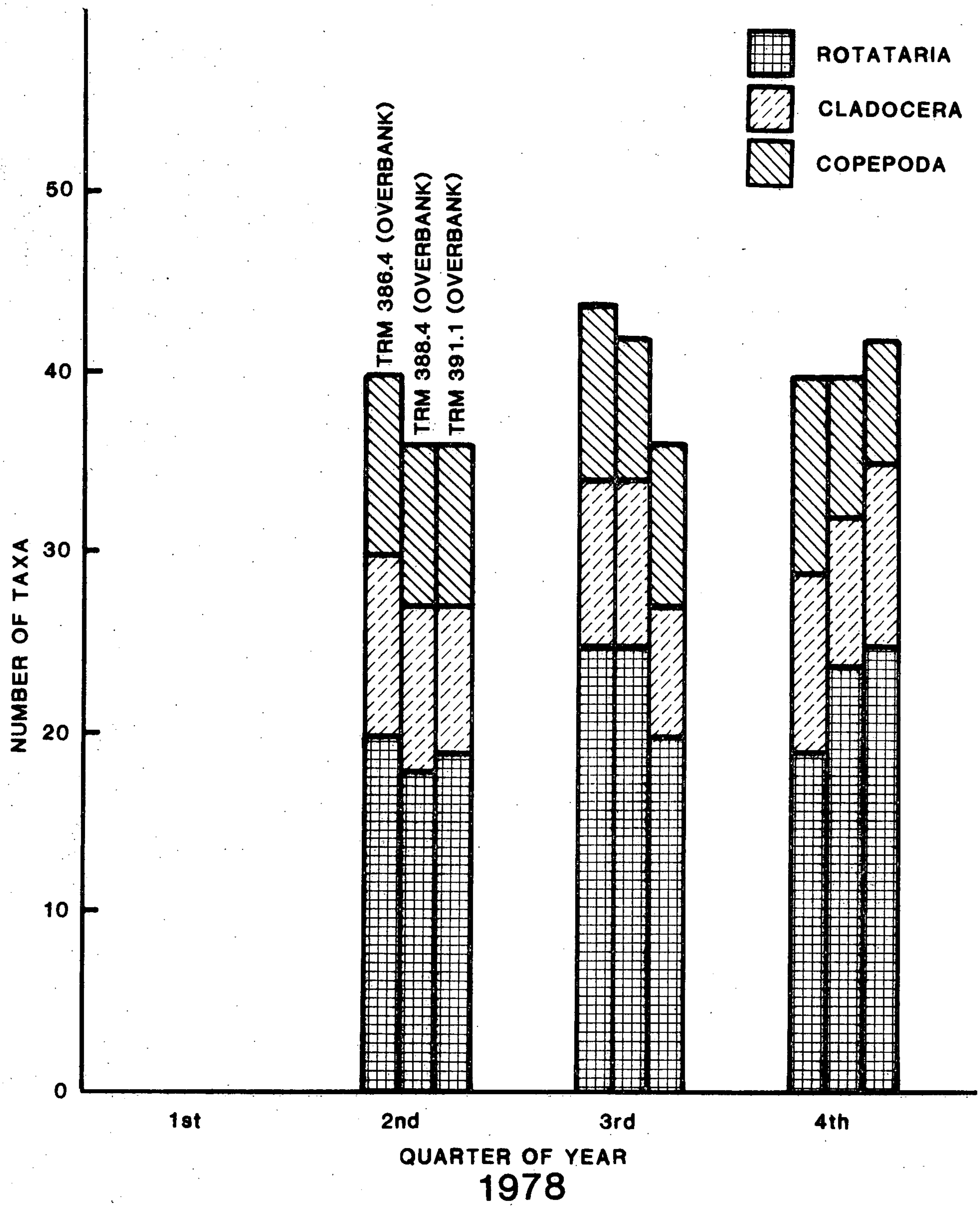


FIGURE 8.13

NUMBER OF TAXA IN EACH ZOOPLANKTON DIVISION BY SEASON AND STATION

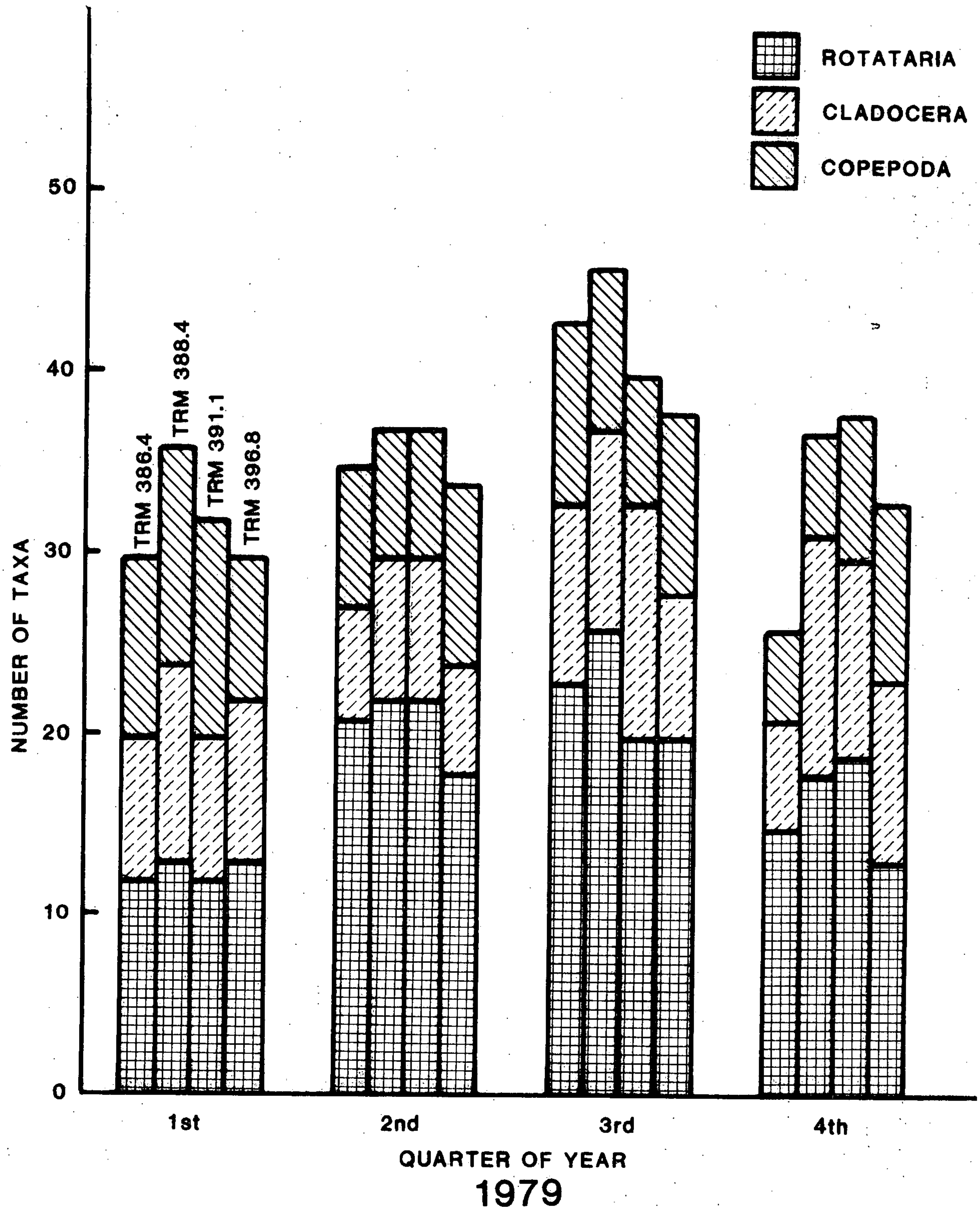
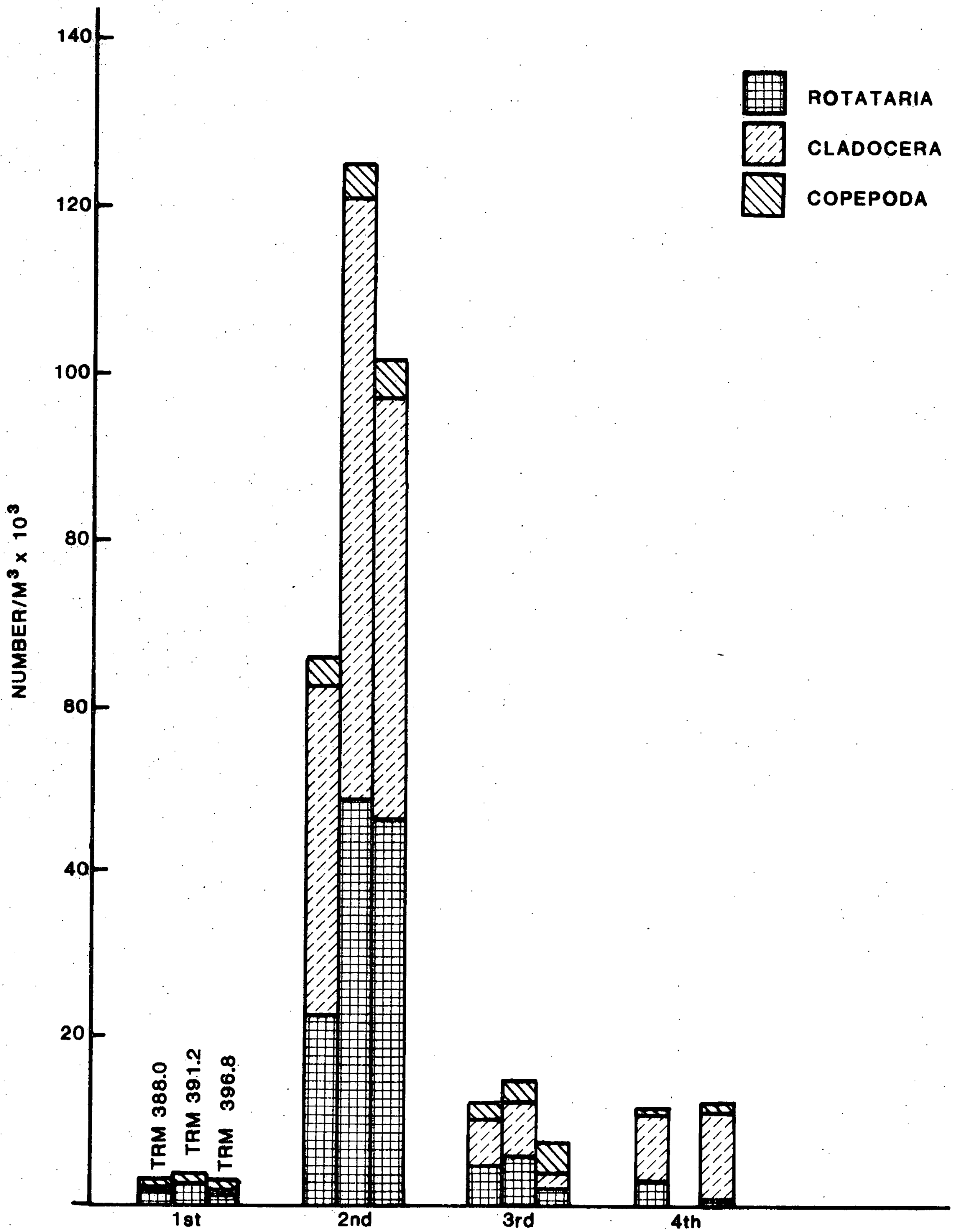


FIGURE 8.14

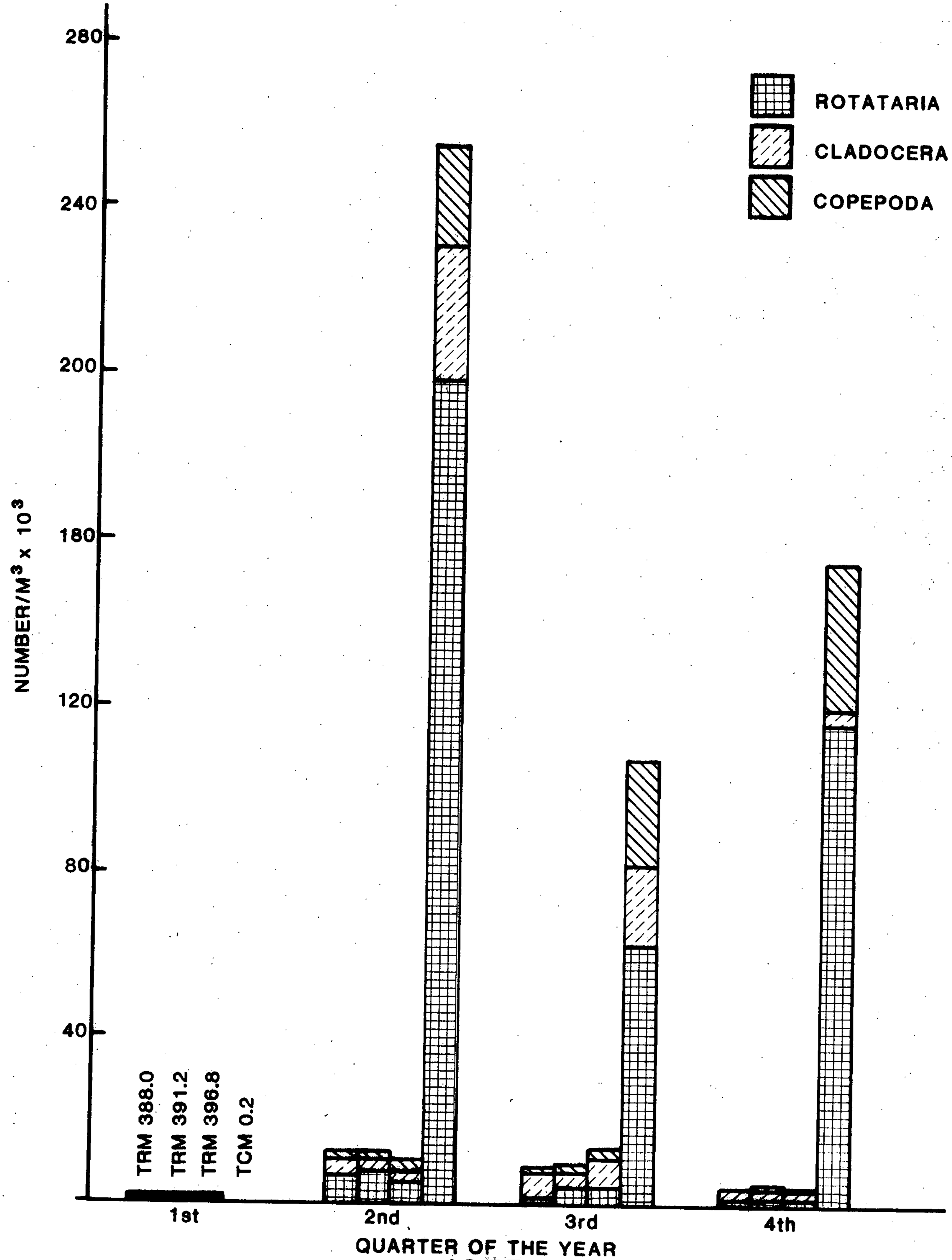
NUMBER OF TAXA IN EACH ZOOPLANKTON DIVISION BY SEASON AND STATION



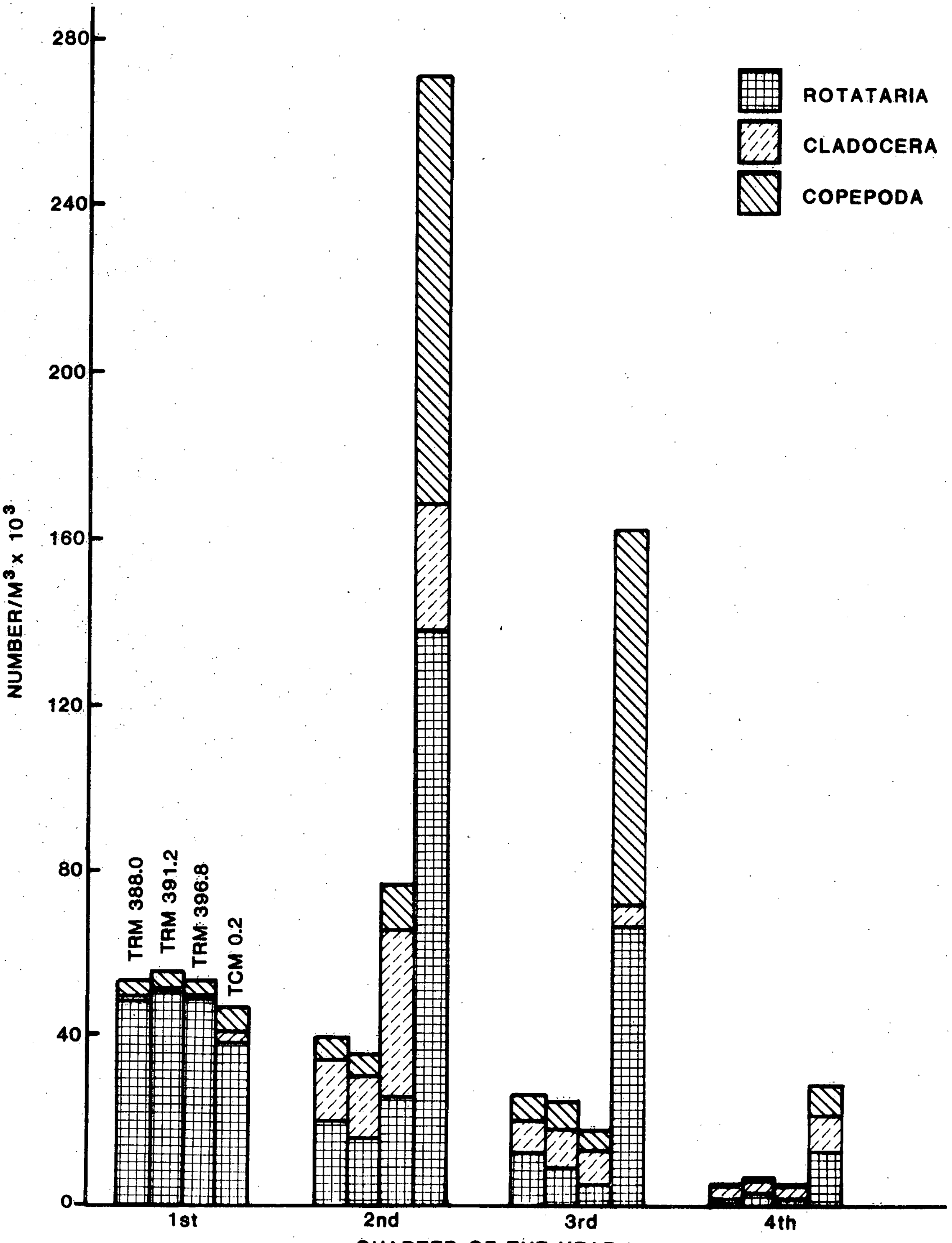
1974

FIGURE 8.15

AVERAGE SEASONAL DENSITY OF ZOOPLANKTON IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT



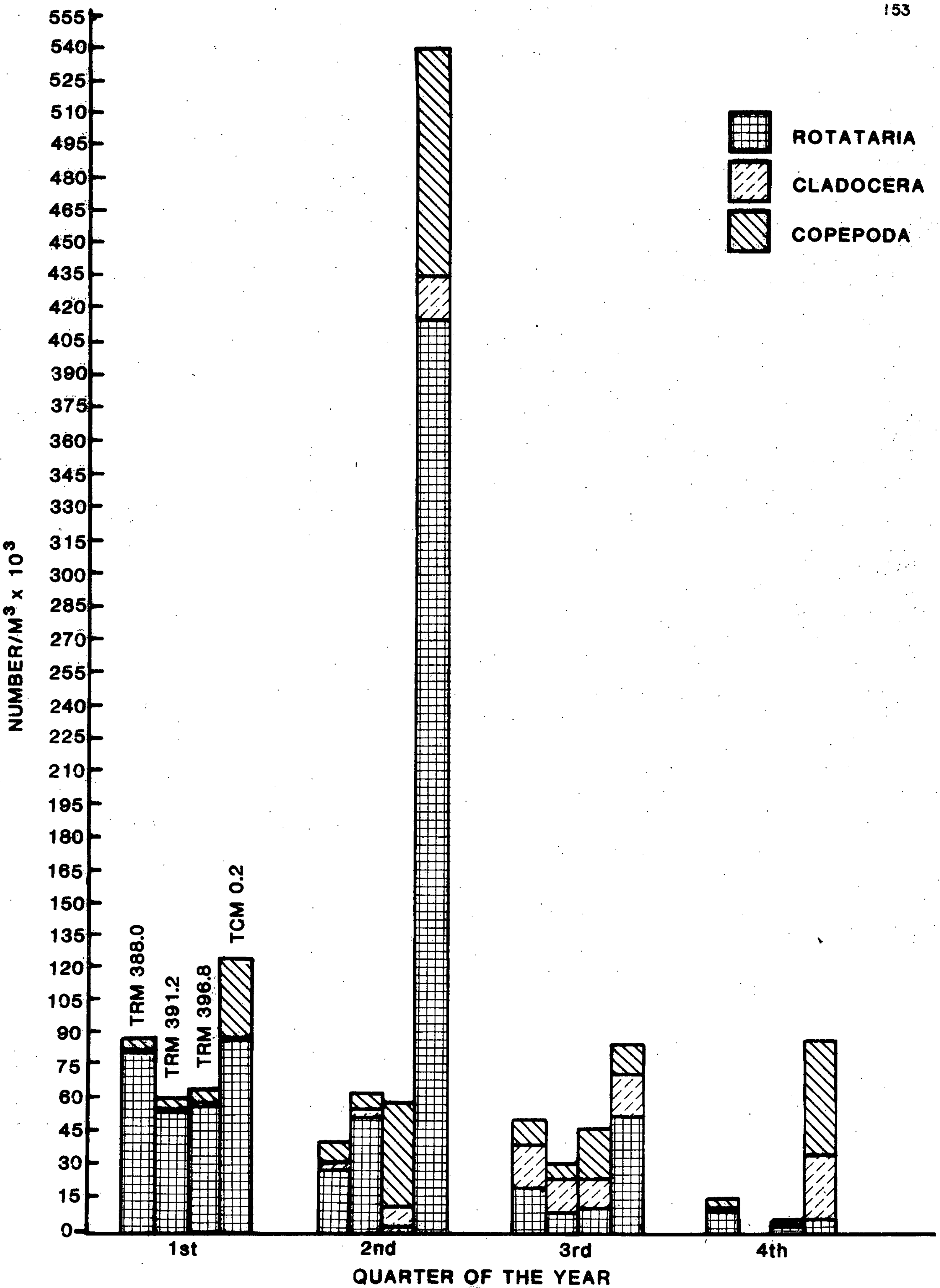
1975
FIGURE 8.16
AVERAGE SEASONAL DENSITY OF ZOOPLANKTON
IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT



1976

FIGURE 8.17

AVERAGE SEASONAL DENSITY OF ZOOPLANKTON IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT



1977

FIGURE 8.18

AVERAGE SEASONAL DENSITY OF ZOOPLANKTON IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT

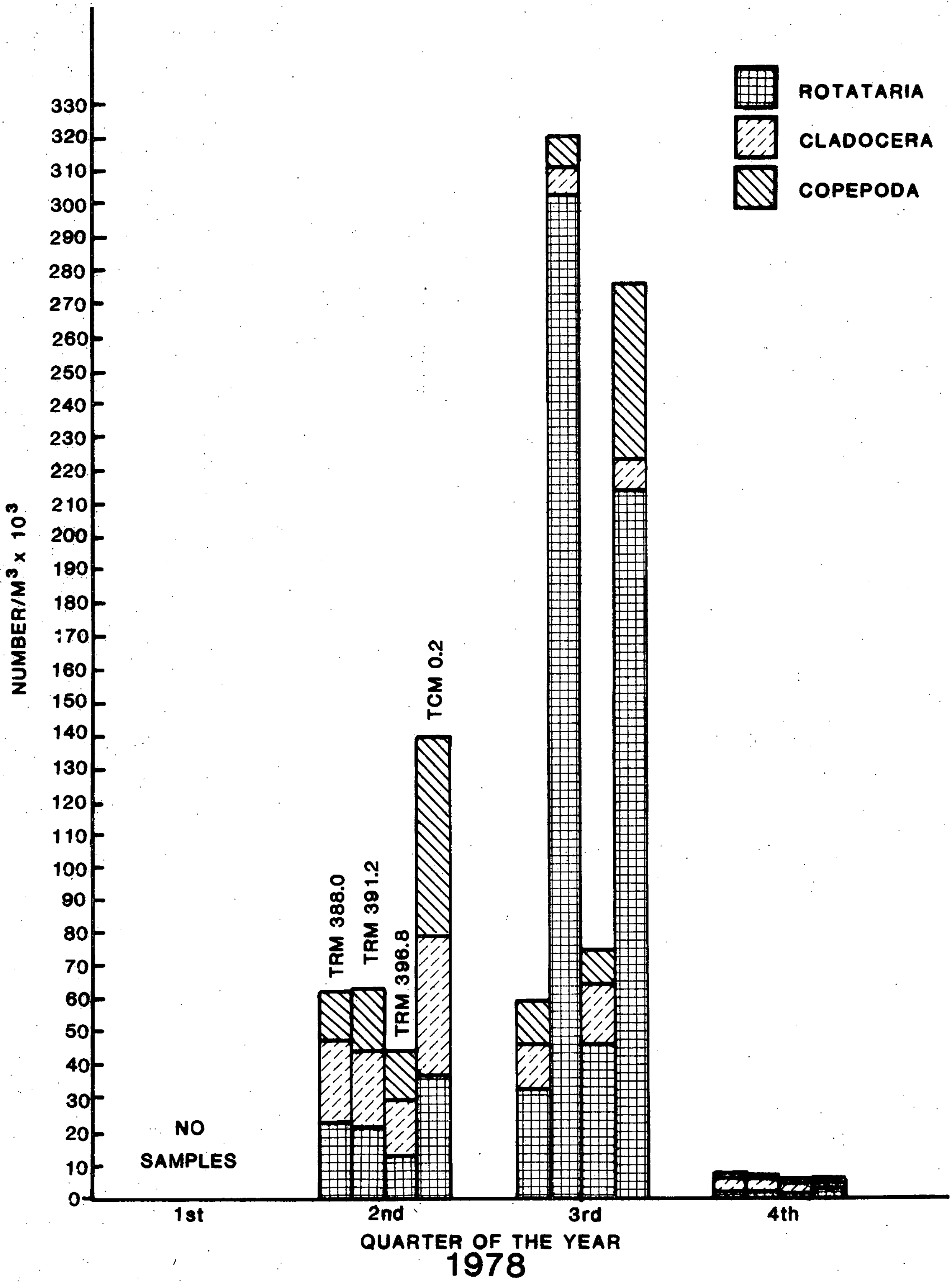


FIGURE 6.19

AVERAGE SEASONAL DENSITY OF ZOOPLANKTON IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT

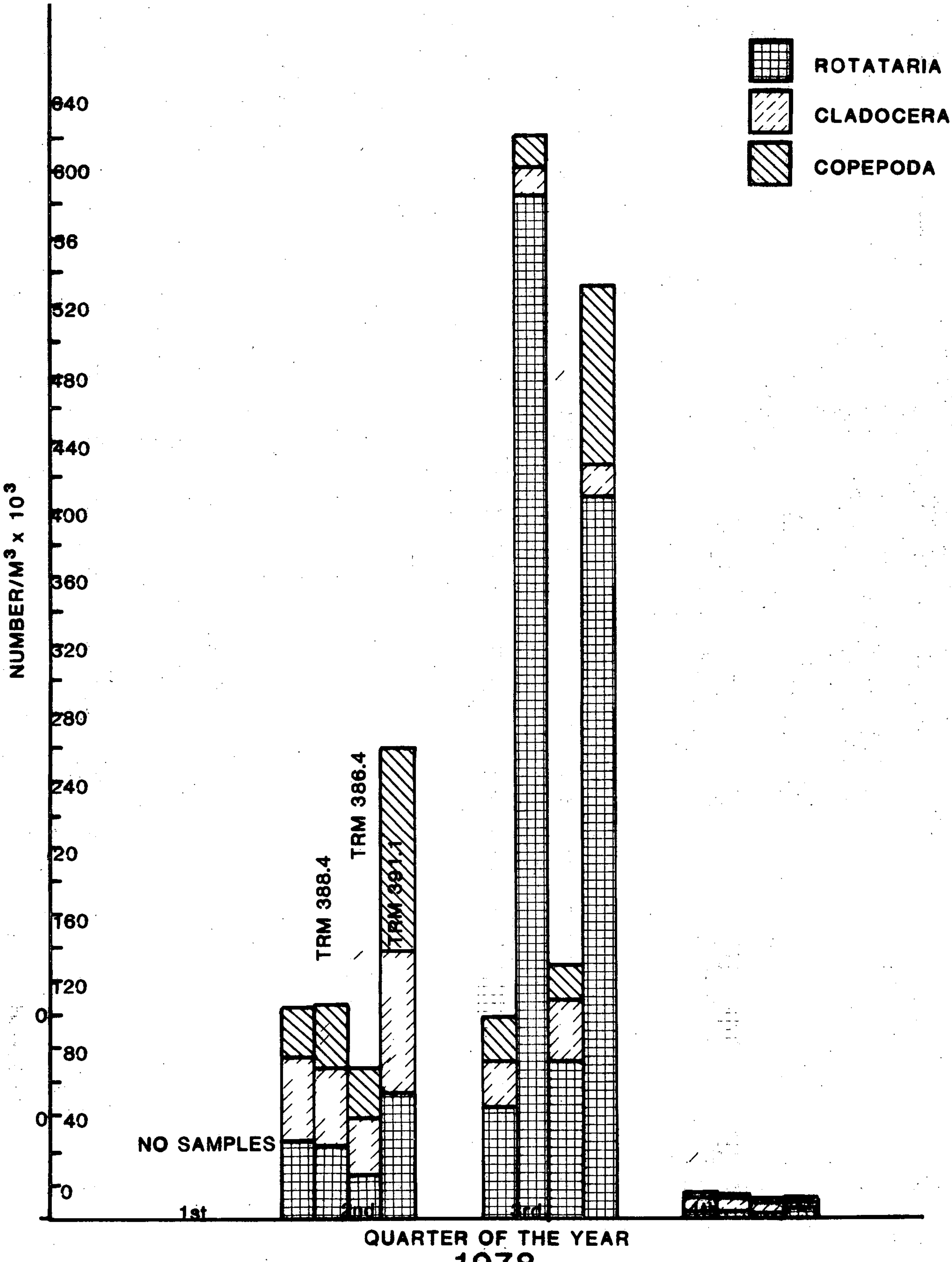
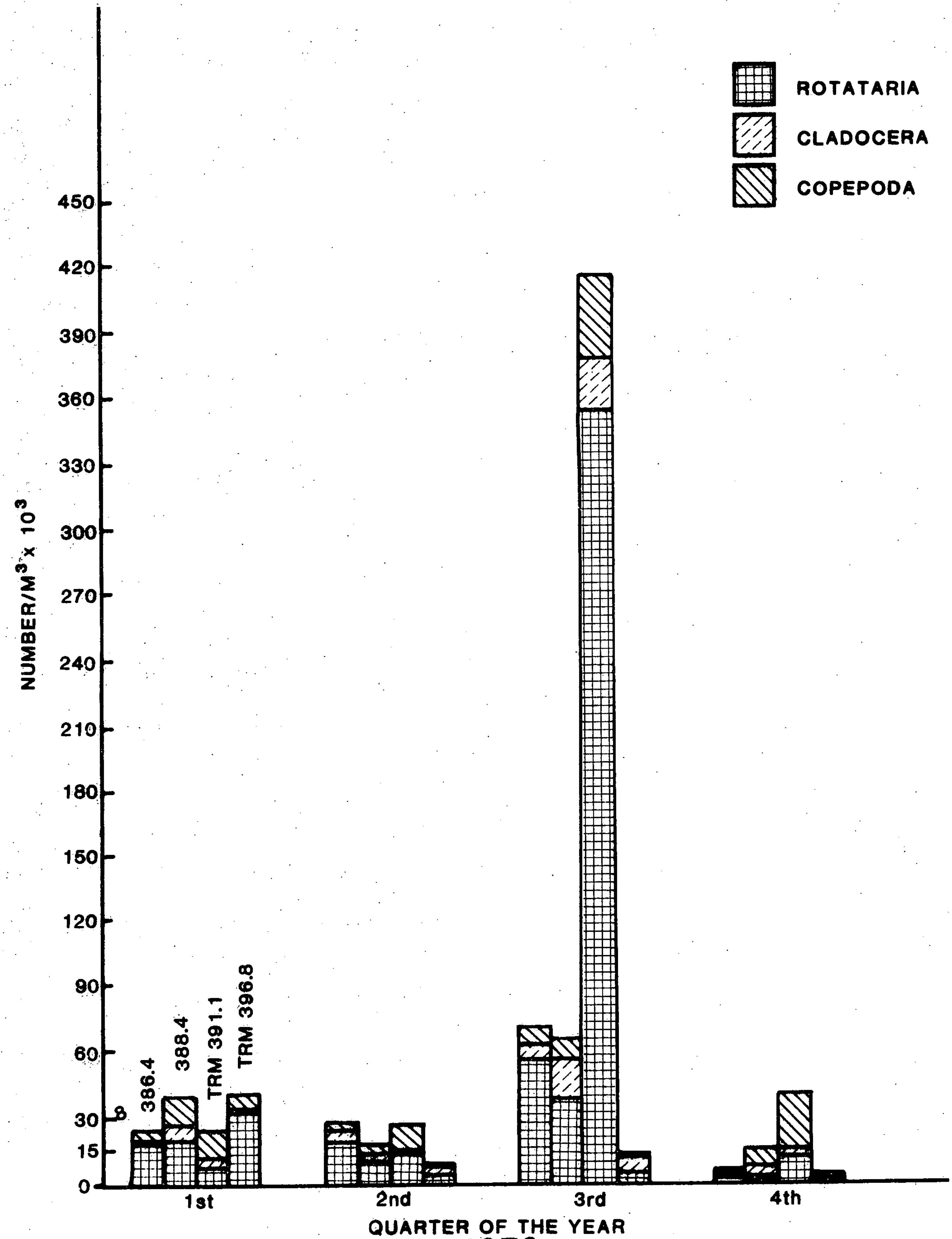


FIGURE 8.20

AVERAGE SEASONAL DENSITY OF ZOOPLANKTON IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT



1979

FIGURE 8.21

AVERAGE SEASONAL DENSITY OF ZOOPLANKTON
IN THE VICINITY OF BELLEFONTE NUCLEAR PLANT

9.0 BENTHIC MACROINVERTEBRATES

Introduction

Benthic aquatic macroinvertebrates are animals that live part or all of their life cycles near or on the bottom of streams or reservoirs. Benthic macroinvertebrates are generally grouped into categories according to characteristics of their feeding habits. The four major groups are (1) grazers and scrapers, (2) shredders, (3) collectors, and (4) predators.

Benthic aquatic macroinvertebrates are a food source for higher forms of aquatic life, mainly fish. They are included in monitoring programs because of their position in the aquatic food chain, and they are useful for detecting the presence of environmental perturbations. Macroinvertebrates with limited powers of locomotion serve as full-time monitors of water quality because they are unable to move or otherwise avoid slugs of polluted water.

Methods and Materials

Ten Ponar benthic grab samples were collected monthly, February through October, at each channel station (TRM 388.0, TRM 391.2, and TRM 396.8) and in Town Creek at mile 0.2.

In 1978-1979, Ponar samples were also collected from the left overbank, both upstream from (TRM 391.1) and within (TRM 389.9, TRM 388.4, and TRM 386.4) the area to be exposed to the thermal plume from BNP. Ponar samples were placed on a No. 48 mesh screen sieve and washed; the remainder of the samples were placed in plastic bags, and preserved with 10 percent formalin.

Macroinvertebrates were also collected at each channel station by retrieving artificial substrates (wire barbeque baskets--volume, 7675 cm^3) filled with washed river rocks, which had been allowed to colonize on the bottom for approximately one month. After retrieval, the substrates were opened and the rocks were gently placed on a standard No. 40 mesh wash screen and rinsed with water. After removal of the organisms by either washing and/or handpicking, the rocks were discarded and the organisms and debris were placed in a plastic bag, labeled, preserved with 10 percent formalin, and returned to the laboratory for processing.

Laboratory processing required washing each sample on a small mesh screen (<340 μm) and removing all macroinvertebrates for identification and enumeration.

Analyses of standing crop data provided a record of abundance of each taxon during each month and year. Diversities ($\bar{d}$) were calculated for the quantitative Ponar samples using the following equation (Patten, 1962):

$$\bar{d} = -\Sigma_{1}^{s} (n_1/n) \log_2 (n_1/n)$$

where s = number of species in a unit area

n_1 = number of individuals belonging to i^{th} species

n = total number of organisms in the unit area

Results

Standing crop data for quantitative macrobenthic samples collected by Ponar grab samples are provided in appendix L for both channel and overbank stations. Corresponding population statistics (mean, range, and standard deviation) are shown in appendix M. Results of artificial substrate sampling are presented in appendix N for the three channel stations.

During the sampling period (1974-1979) a total of 97 macroinvertebrate taxa (Ponar samples) were collected in the vicinity of BNP (table 9.1). Dominant taxa (occurring in densities over $100/m^2$ at least once during the monitoring period) for channel and overbank stations were as follows:

Channel	Overbank	
Corbicula	Corbicula	Caenis
Limnodrilus	Limnodrilus	Cryptochironomus
Chaoborus	Chaoborus	Glyptotendipes
Branchiura	Branchiura	Hirudinea
Dicrotendipes	Dicrotendipes	Hyaella
Procladius	Procladius	Parachironomus
Hexagenia	Hexagenia	Polypedilum
Xenochironomus		Enallagma
Coelotanypus	Coelotanypus	Paratendipes
Pleurocera	Ablabesmyia	Rheotanytarsus
	Chironomus	Spaerium

(Ponar and artificial substrate samples) by station and year are illustrated in figures 9.1 to 9.8. Yearly maximum densities of individuals at each station are shown in figures 9.9 and 9.10.

The soft substrates and quiescent nature of the overbank habitat supported a much more diverse assemblage of macroinvertebrates. While overbank $\bar{d}$ values remained high (>1), channel diversities often fell below 1.0. Lower $\bar{d}$ values in the channel are probably due to the abundance of Corbicula which is well suited to the hard gravel substrate typically observed in the vicinity of the BNP site.

Standing crop values were also much higher at the overbank stations than at the channel stations, except at TRM 388.0, where channel values were similar to overbank values. This station was similar to other channel stations during the first three years of monitoring. However, in 1977-1979, densities of macroinvertebrates increased at TRM 388.0. This increase was due to dredging at this station by a commercial sand and gravel company, which caused a significant change in substrate (increase in silt and clay). A more detailed description of the impact to this station and potentials for altering other monitoring stations is described in the Bellefonte Nuclear Plant Construction Effects Monitoring Report (TVA, 1980) and in Chapter 5.0 of this report.

Data for macroinvertebrates collected from artificial substrates are tabulated in appendix N. Vandalism or failure to relocate some artificial substrates resulted in the loss of 148 of 396 substrates placed during the five year period. The loss of these data prevented complete temporal and spatial comparisons of macroinvertebrate populations. Since substrates were replaced monthly, colonization depended largely upon drift organisms. Seasonal variation were related to the cyclic life history of many of the benthic organisms.

The yearly maximum, minimum, and mean standing crop values for benthic macroinvertebrates by station are summarized below:

Station		Organisms/m^2 1974	1975	1976	1977	1978	1979
TCM 0.2	Max	208	279	201	485	587	407
	Min	18	46	25	62	34	42
	Mean	8	111	76	266	145	178
TRM 388.0 (channel)	Max	252	176	325	624	763	589
	Mean	11	34	5	26	231	176
	Mean	62	100	70	253	478	390
TRM 391.2 (channel)	Max	67	107	118	149	125	199
	Min	3	17	3	4	2	4
	Mean	33	57	47	57	54	73
TRM 396.8 (channel)	Max	66	107	216	336	274	175
	Min	4	24	4	2	9	6
	Mean	24	63	53	99	99	67
TRM 386.4 (left overbank)	Max	X[a]	X	X	X	1082	1210
	Min	X	X	X	X	285	216
	Mean	X	X	X	X	678	583
TRM 388.4 (left overbank)	Max	X	X	X	X	1085	1225
	Min	X	X	X	X	290	277
	Mean	X	X	X	X	581	231
TRM 389.9 (left overbank)	Max	X	X	X	X	591	231
	Min	X	X	X	X	122	12
	Mean	X	X	X	X	335	92
TRM 391.1 (left overbank)	Max	X	X	X	X	1036	891
	Min	X	X	X	X	224	178
	Mean	X	X	X	X	592	535

a. X indicates missing samples.

Thirty-nine taxa were collected from artificial substrates during the preoperational monitoring period (table 9.2). Taxa which occurred most frequently were Limnodrilus, Hyaella, *Caenis*, *Chironomus*, *Corbicula*, *Stenonema*, and *Cyrnellus*. Other macroinvertebrates occurring less frequently are shown in table 9.3.

Literature Cited

Patten, B. C. 1962. "Species Diversity in Net Phytoplankton of Raritan Bay." J. Mar. Res. 21:158-163.

Tennessee Valley Authority. 1980. Bellefonte Nuclear Plant Construction Effects Monitoring Report, 1973-1977.

Table 9.1

TAXONOMIC LIST OF BENTHIC MACROINVERTEBRATES IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - GUNTERSVILLE RESERVOIR 1974-1979

AMPHIPODA
- *Crangonyx*
- *Gammarus*
- *Hyalella*
- *Hyalella azteca*

BASOMMATOPHORA
- *Physa*

COLEOPTERA
- *Dubiraphia*

DECAPODA
- *Orconectes*

DIPTERA
- *Ablabesmyia*
- *Bezzia*
- *Bezzia varicolor*
- Ceratopogonidae
- *Chaoborus*
- Chironomidae
- *Chironomus*
- *Chironomus tentans*
- *Chrysops*
- *Coelotanypus*
- *Cricotopus*
- *Cryptochironomus*
- Culicidae
- *Culicoides*
- *Dicrotendipes*
- *Epoicocladius*
- *Glyptotendipes*
- *Parachironomus*
- *Paratendipes*
- *Pentaneura*
- *Phaenopsectra*
- *Polypedilum*
- *Procladius*
- *Pseudochironomus*
- *Rheotanytarsus*
- *Smittia*
- *Stenochironomus*
- *Tanypus*
- *Tanytarsus*
- *Tribelos*
- *Xenochironomus*

EPHEMEROPTERA
- Baetidae
- *Caenis*
- *Caenis simulans*
- *Hexagenia atrocaudata*
- *Hexagenia bilineata*
- *Hexagenia limbata*
- *Siphlonurus*
- *Stenacron*
- *Stenonema*

EULAMELLIBRANCHIA
- *Anodonta suborbiculata*
- *Megalonaias gigantea*
- *Quadrula quadrula*
- *Truncilla donaciformis*

GORDIIDA
- Nemata
- *Paragordius*

GYMNOLAEMATA
- *Pectinatella magnifica*

HETERODONTA
- *Corbicula manilensis*
- *Psidium*
- *Sphaerium*

ISOPODA
- *Lirceus*

MESOGASTROPODA
- *Amnicola*
- *Campeloma*
- *Campeloma crassula*
- *Pleurocera*
- *Pleurocera canaliculatum*
- *Pleurocera canaliculatum filum*
- *Somatogyrus*
- Viviparidae
- *Viviparus*

NEUROPTERA
- *Sialis*

Table 9.1 (continued)

ODONATA
- *Argia*
- Corduliidae (Epitheca)
- *Didymops*
- *Dromogomphus*
- *Enallagma*
- *Gomphus*
- *Ischnura*
- *Macromia*
- *Neurocordulia*
- *Perithemis tenera*

OLIGOCHAETA (Subclass)
- *Branchiura*
- *Branchiura sowerbyi*
- *Limnodrilus*
- *Limnodrilus claparedeianus*
- Lumbuculidae
- Tubificidae

PHARYNGOBDELLIDA
- Erpobdellidae

RHYNCHOBDELLIDA
- Hirudinea

TRICHOPTERA
- *Agraylea*
- *Cheumatopsyche*
- *Crynellus fraternus*
- *Hydropsyche*
- *Hydroptila*
- *Neureclipsis*
- *Oecetis*

TRICLADIDA
- *Cura foremanii*
- *Dugesia*
- *Dugesia tigrina*
- Planariidae

Grand Total Taxa - 97

Table 9.2

NUMBER OF SAMPLING PERIODS THAT THE FOLLOWING TAXA COLONIZED ARTIFICIAL SUBSTRATES - 1974-1979

	TRM 388.0	TRM 391.2	TRM 396.8	Total frequency for each taxa
AMPHIPODA				
Gammarus	3	1	2	6
Hyalella	24	19	16	59
DECAPODA				
Orconectes	5	9	9	23
DIPTERA				
Ablabesmyia	7	6	8	21
Chironomus	13	19	14	46
Coelotanypus	6	5	4	15
Cricotopus	9	8	8	25
Cryptochironomus	2	4	5	11
Glyptotendipes	8	3	6	17
Parachironomus	4	5	6	15
Polypedilum	8	4	5	17
Procladius	4	5	3	12
Pseudochironomus	3	6	7	16
Rheotanytarsus	5	7	-	12
EPHEMEROPTERA				
Caenis	17	14	16	47
Cloeon	3	2	1	6
Hexagenia	6	14	6	26
Stenacron	10	9	11	30
Stenonema	14	11	14	39
Tricorythodes	5	3	-	8
HETERODONTA				
Corbicula	10	17	14	41
ISOPODA				
Lirceus	3	5	4	12
MESOGASTROPODA				
Pleurocera	5	3	2	10
ODONATA				
Argia	10	10	12	32
Dromogomphus	1	3	1	5
Enallagma	7	7	9	22
Gomphus	2	4	1	7

Table 9.2 (continued)

	TRM 388.0	TRM 391.2	TRM 396.8	Total frequency for each taxa
OLIGOCHAETA				
<u>Branchiura</u>	10	20	2	32
<u>Limnodrilus</u>	23	32	17	72
RHYNCHOBDELLIDA				
Hirudinea	9	–	4	13
TRICHOPTERA				
<u>Agraylea</u>	8	5	6	19
<u>Cheumatopsyche</u>	9	9	8	26
<u>Cyrnellus</u>	15	13	11	39
<u>Neureclipsis</u>	12	9	9	30
<u>Oecetis</u>	1	1	2	4
<u>Polycentropus</u>	3	1	–	4
Psychomyiidae Genus A	7	8	5	20
TURBELLARIA				
<u>Cura</u> <u>foremanii</u>	7	6	5	18
<u>Dugesia</u>	2	4	4	10
Total Number of Taxa	39	38	36	
Number of Taxa During Entire Sampling Period				39

Table 9.3

BENTHIC ORGANISMS THAT COLONIZED ARTIFICIAL SUBSTRATES PERIODICALLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1974-1978

Amnicola
Campeloma
Chaoborus
Chironomidae
Coenagrionidae
Conchapelopia
Crangonyx
Culicoids
Didymops
Dubiraphia
Eukiefferiella
Gyralens
Hydropsychidae
Macronia
Pentaneura
Physa
Psectrocladius
Psychomyiidae
Sialis
Smittia
Somatogyrus
Xenochironomus

Total Number of Taxa - 22

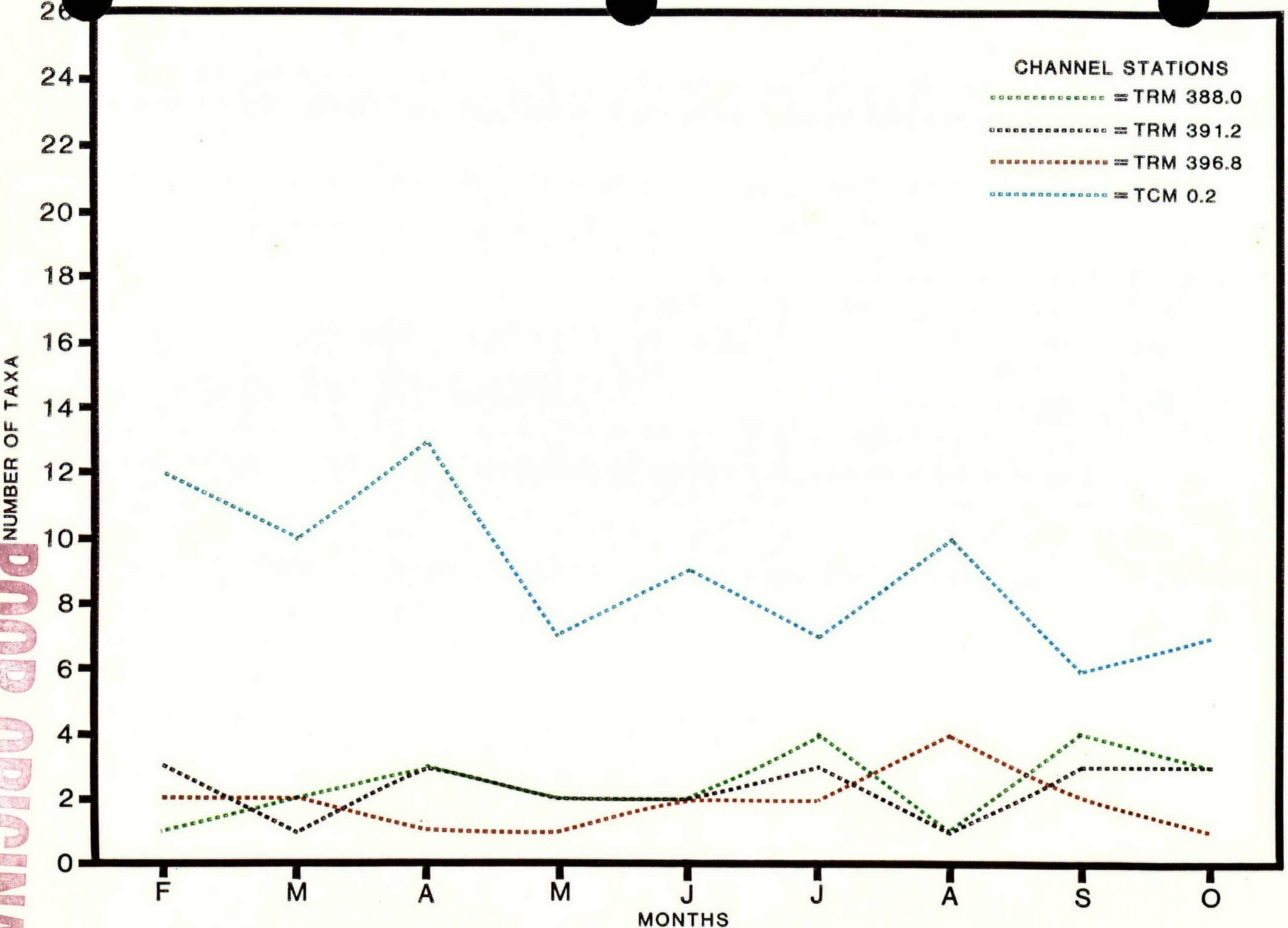


FIGURE 9.1 TOTAL NUMBER OF BENTHIC MACROINVERTEBRATE TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1974

POOR ORIGINAL

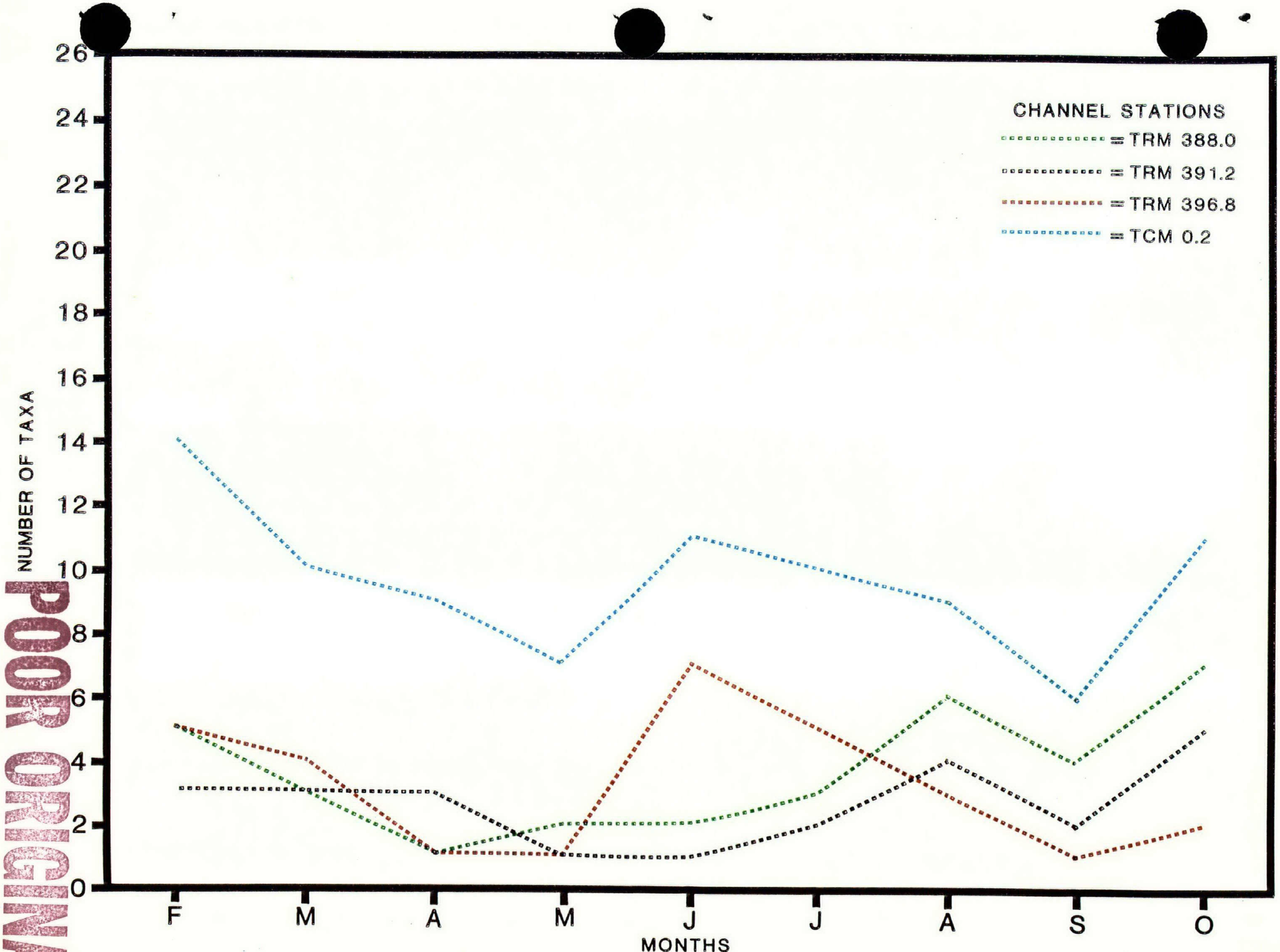


FIGURE 9.2 TOTAL NUMBER OF BENTHIC MACROINVERTEBRATE TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1975

POOR ORIGINAL

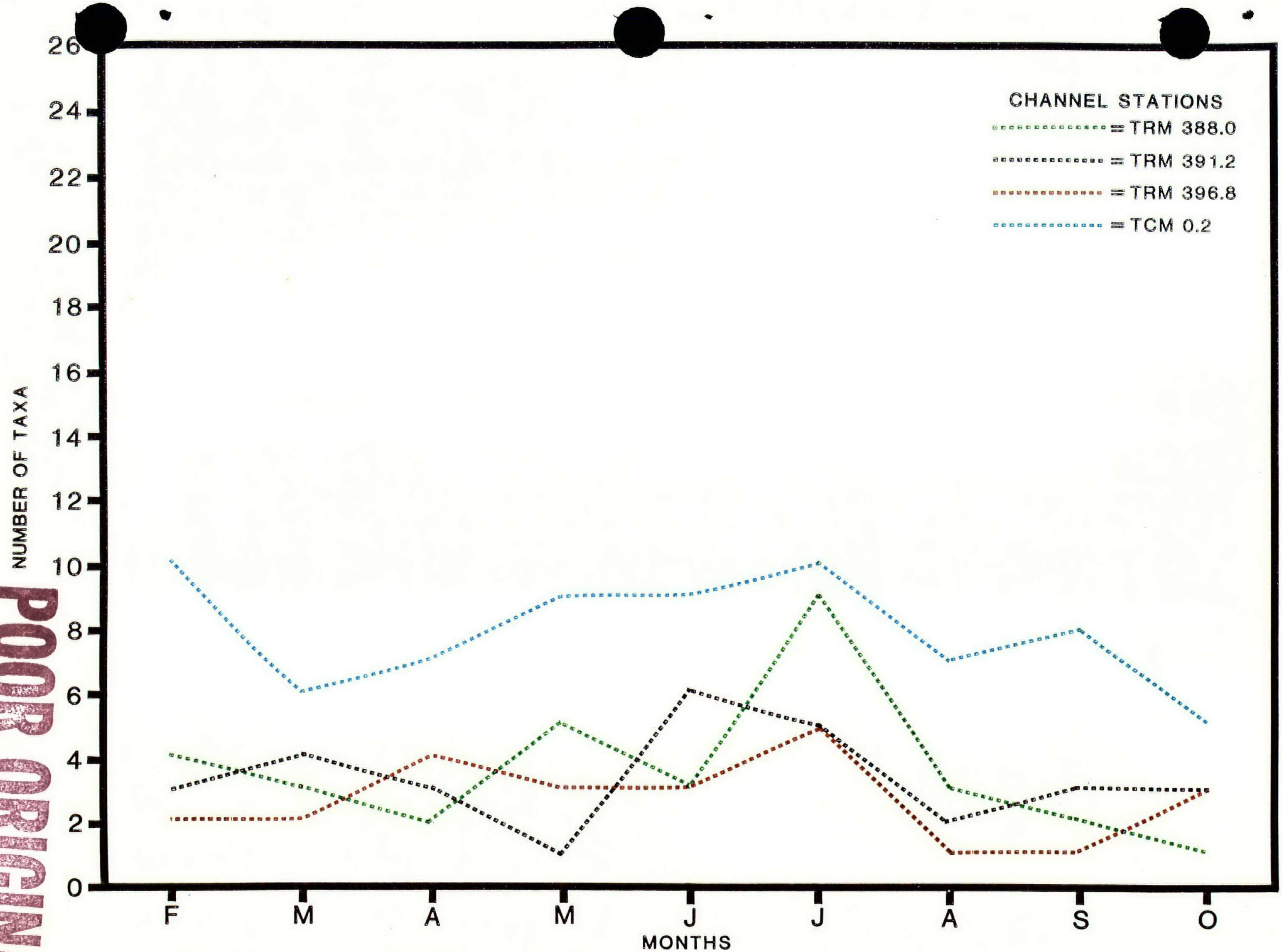


FIGURE 9.3 TOTAL NUMBER OF BENTHIC MACROINVERTEBRATE TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1976

POOR ORIGINAL

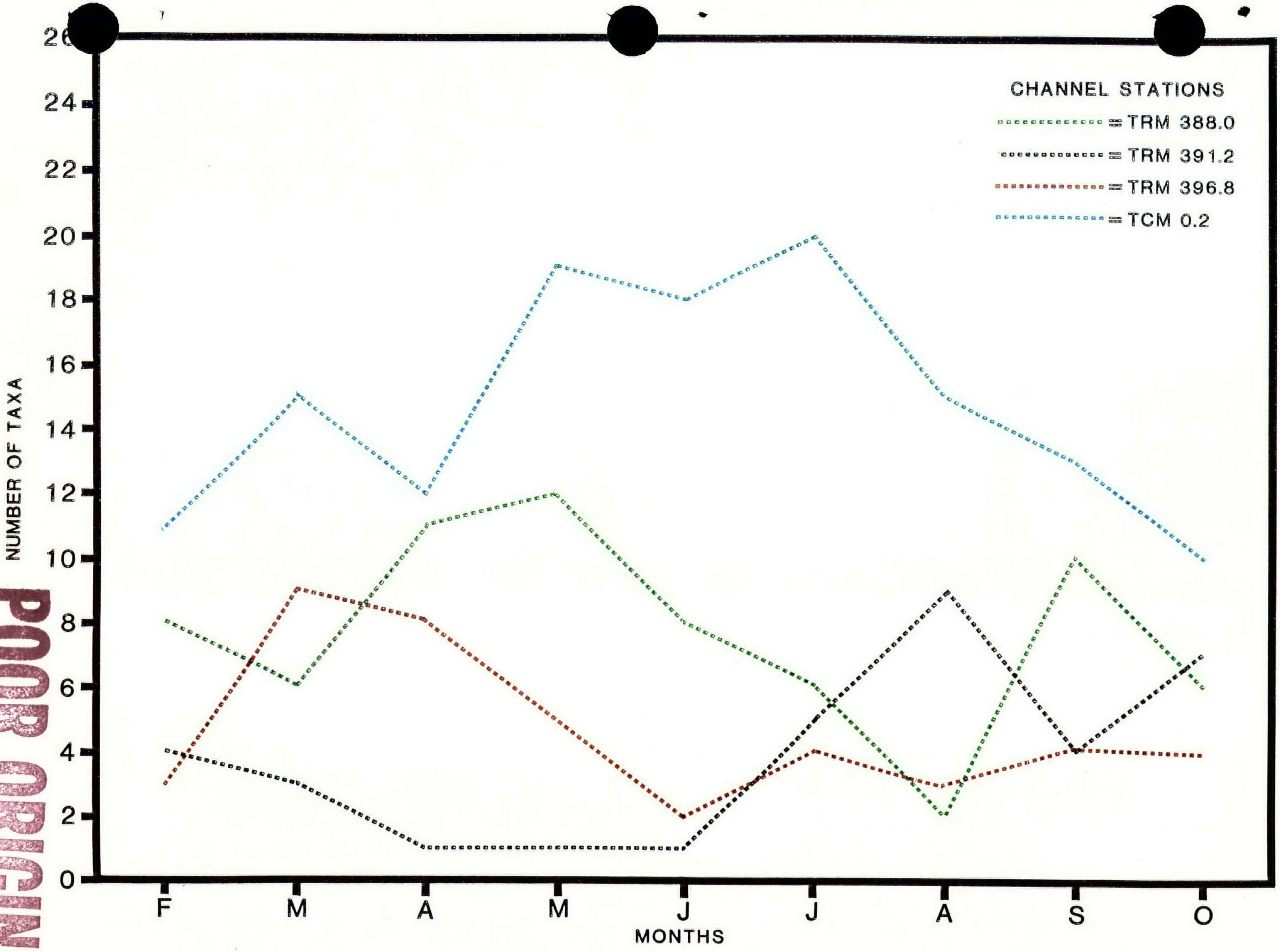
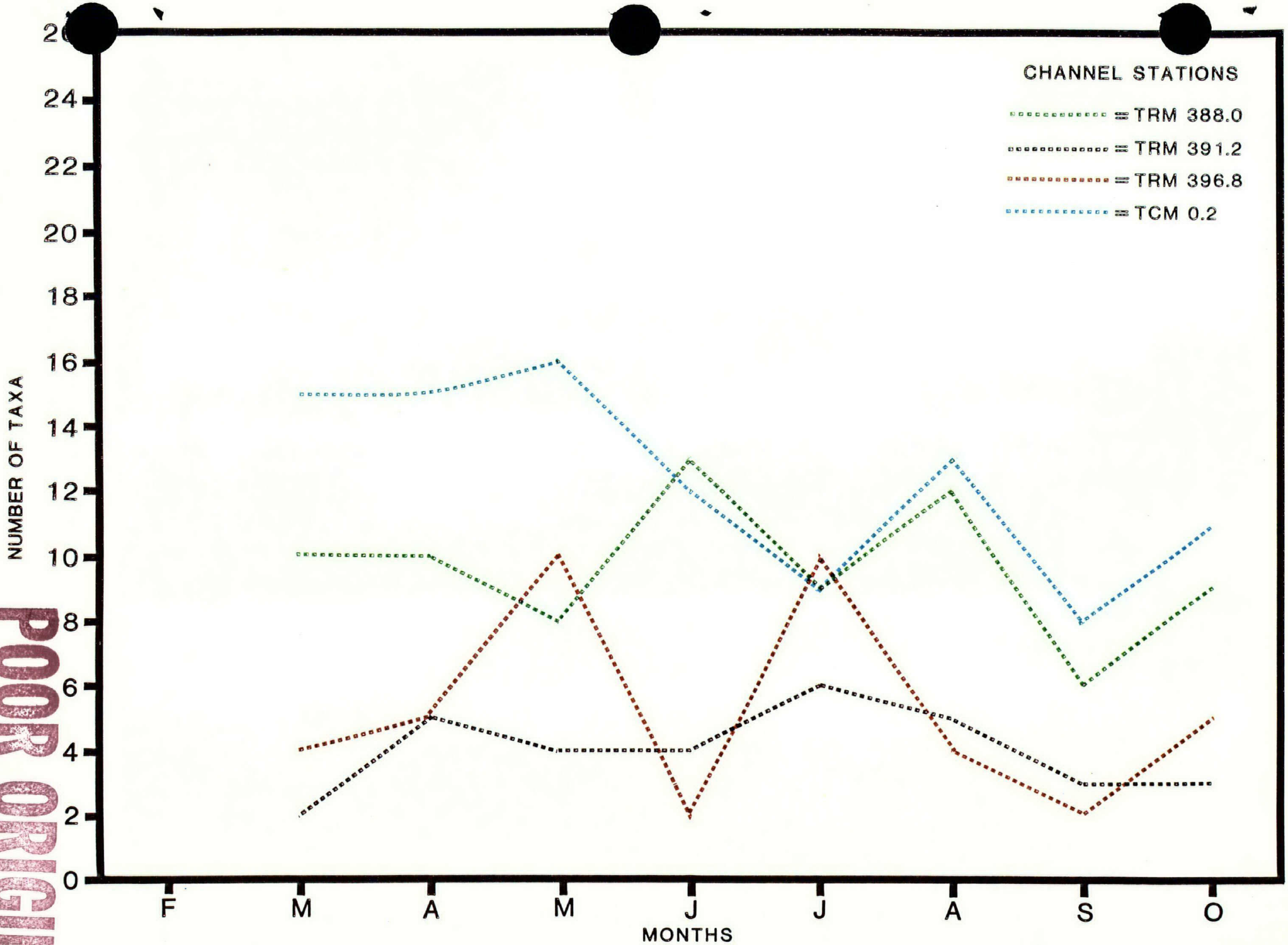


FIGURE 9.4 TOTAL NUMBER OF BENTHIC MACROINVERTEBRATE TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1977

POOR ORIGINAL



CHANNEL 9.5 TOTAL NUMBER OF BENTHIC MACROINVERTEBRATE TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1978

POOR ORIGINAL

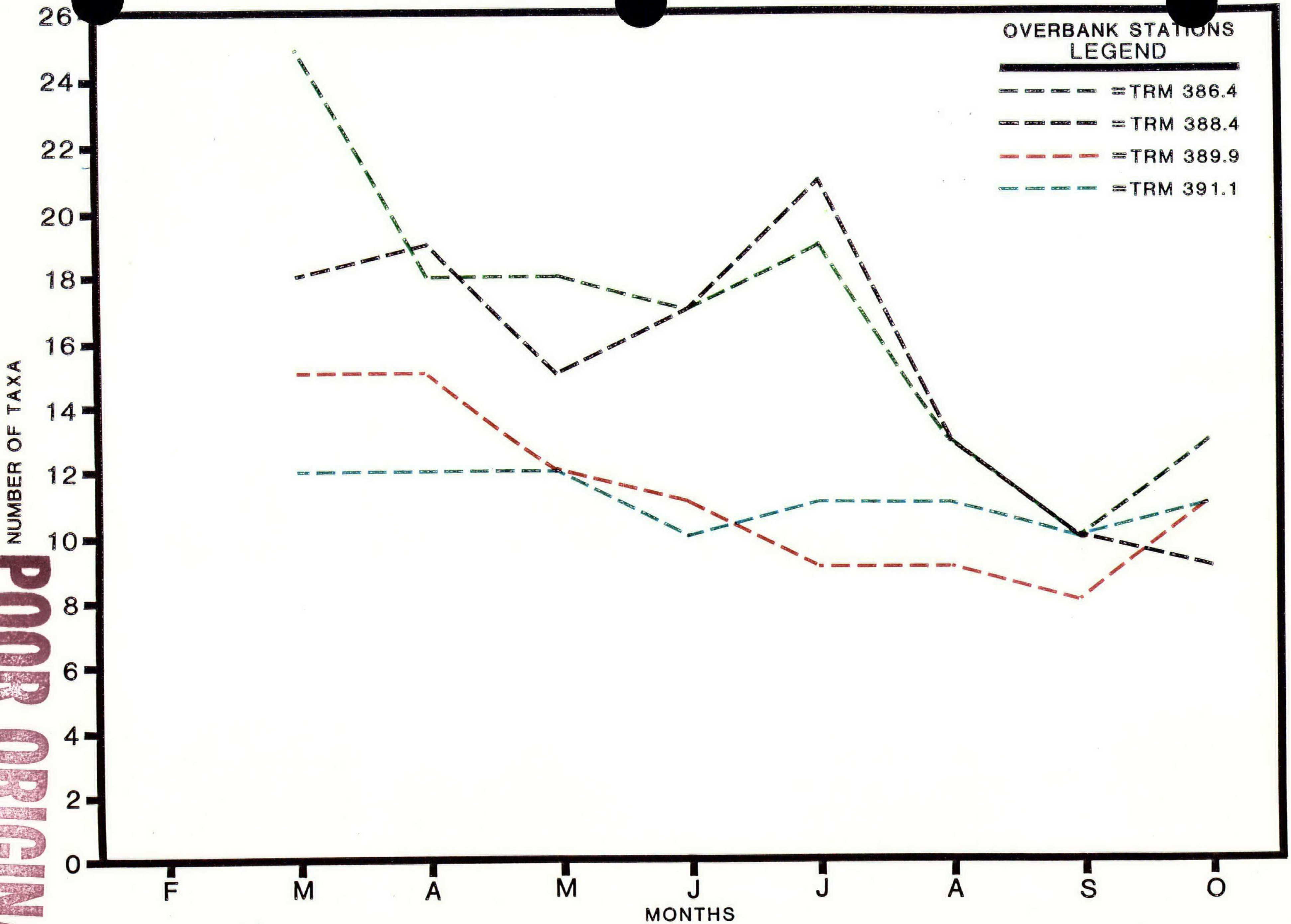


FIGURE 9.6 TOTAL NUMBER OF BENTHIC MACROINVERTEBRATE TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1978

POOR ORIGINAL

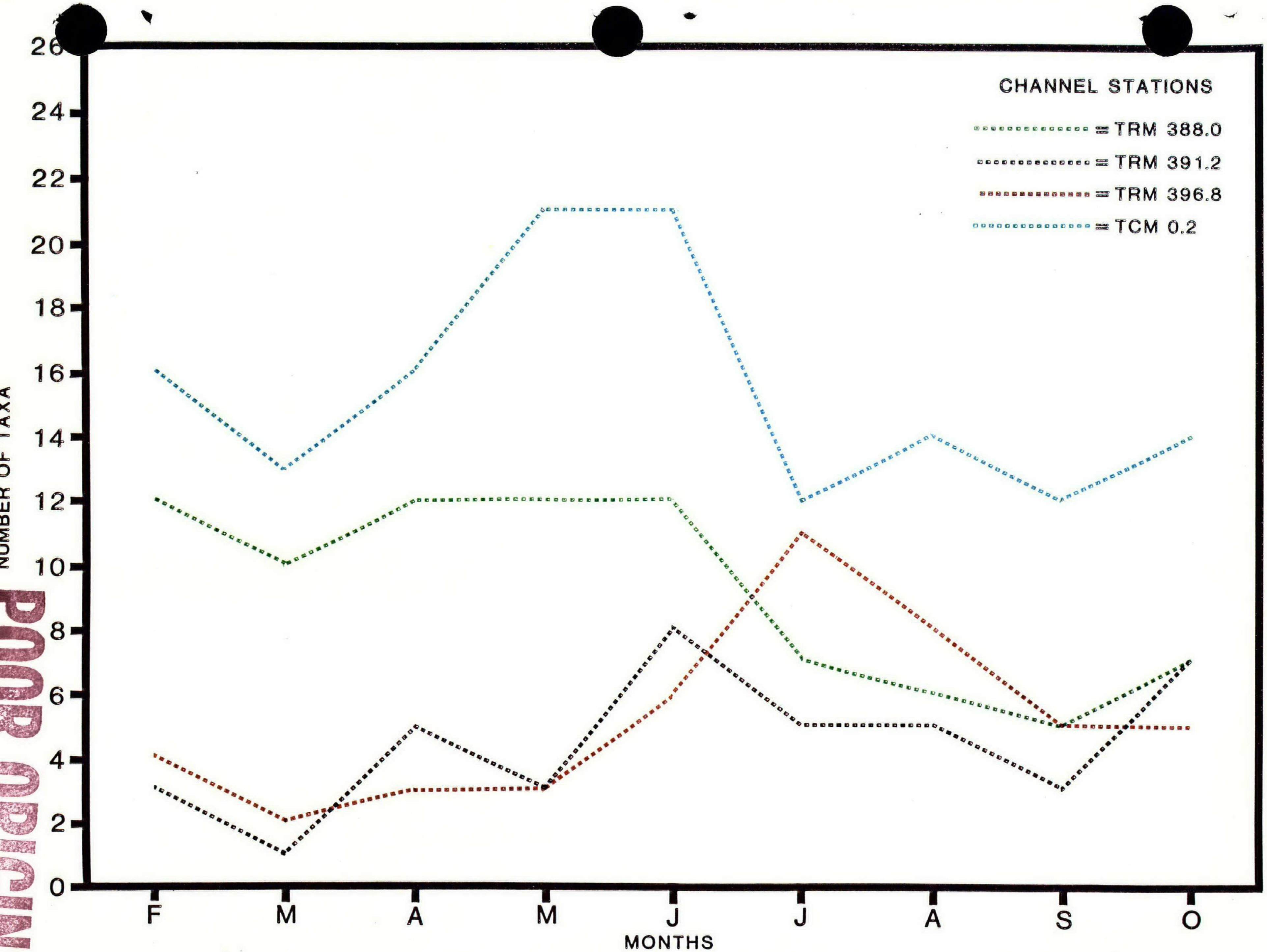


FIGURE 9.7 TOTAL NUMBER OF BENTHIC MACROINVERTEBRATE TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1979

POOR ORIGINAL

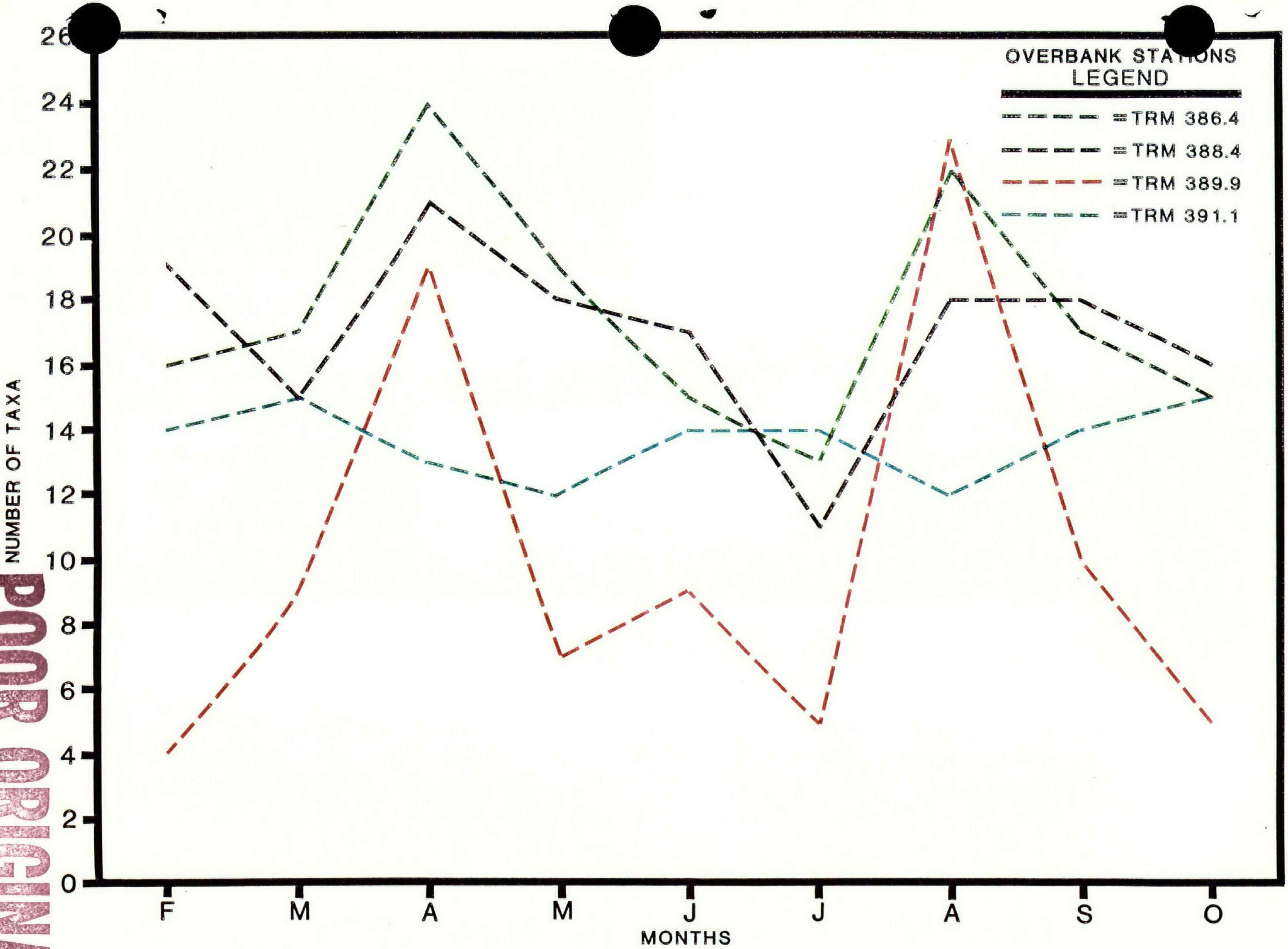


FIGURE 9.8 TOTAL NUMBER OF BENTHIC MACROINVERTEBRATE TAXA COLLECTED MONTHLY IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT - 1979

POOR ORIGINAL

POOR ORIGINAL

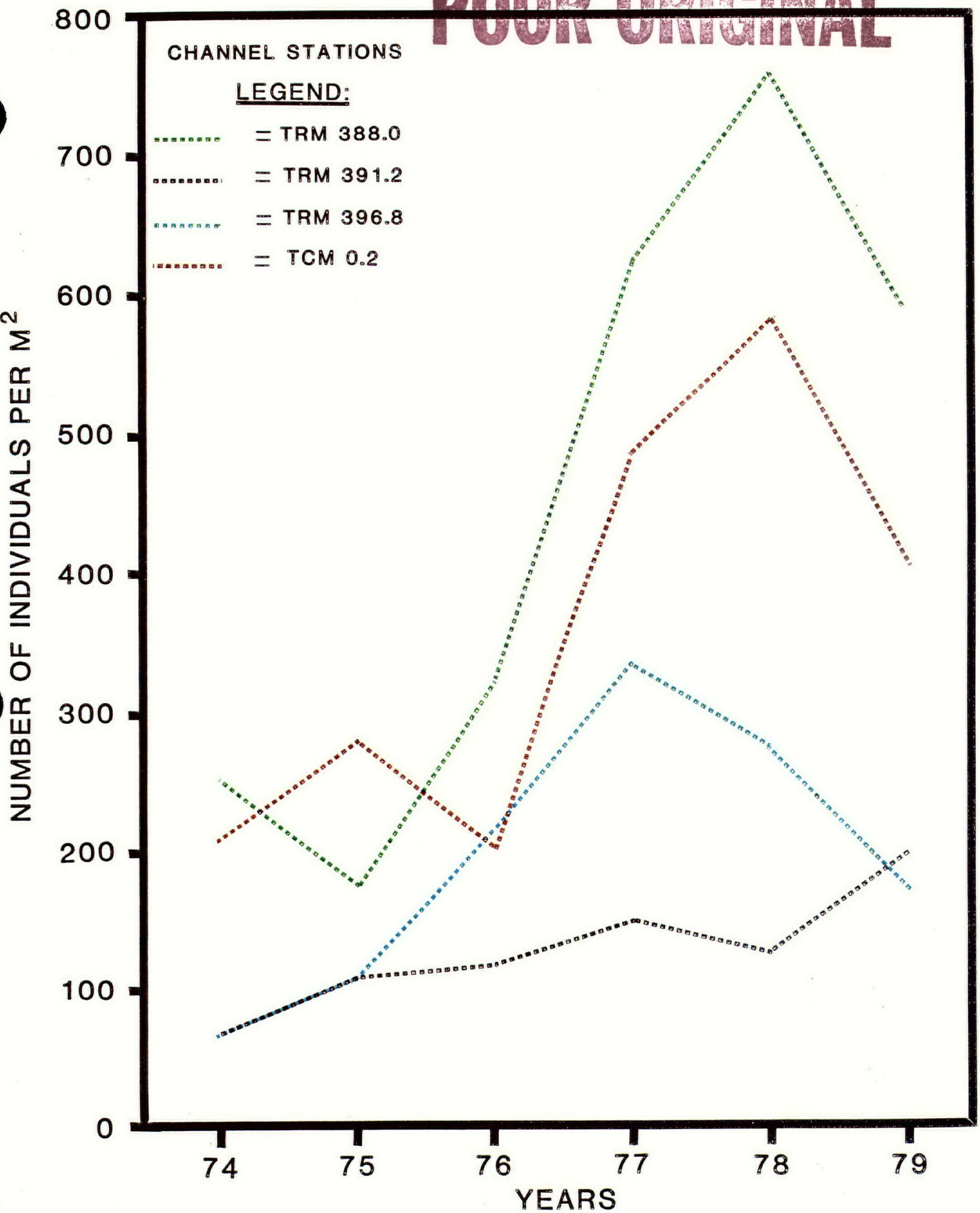


FIGURE 9.9 - CHANNEL STATIONS

MAXIMUM YEARLY DENSITY OF BENTHIC MACROINVERTEBRATES COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT 1974-1979

POOR ORIGINAL

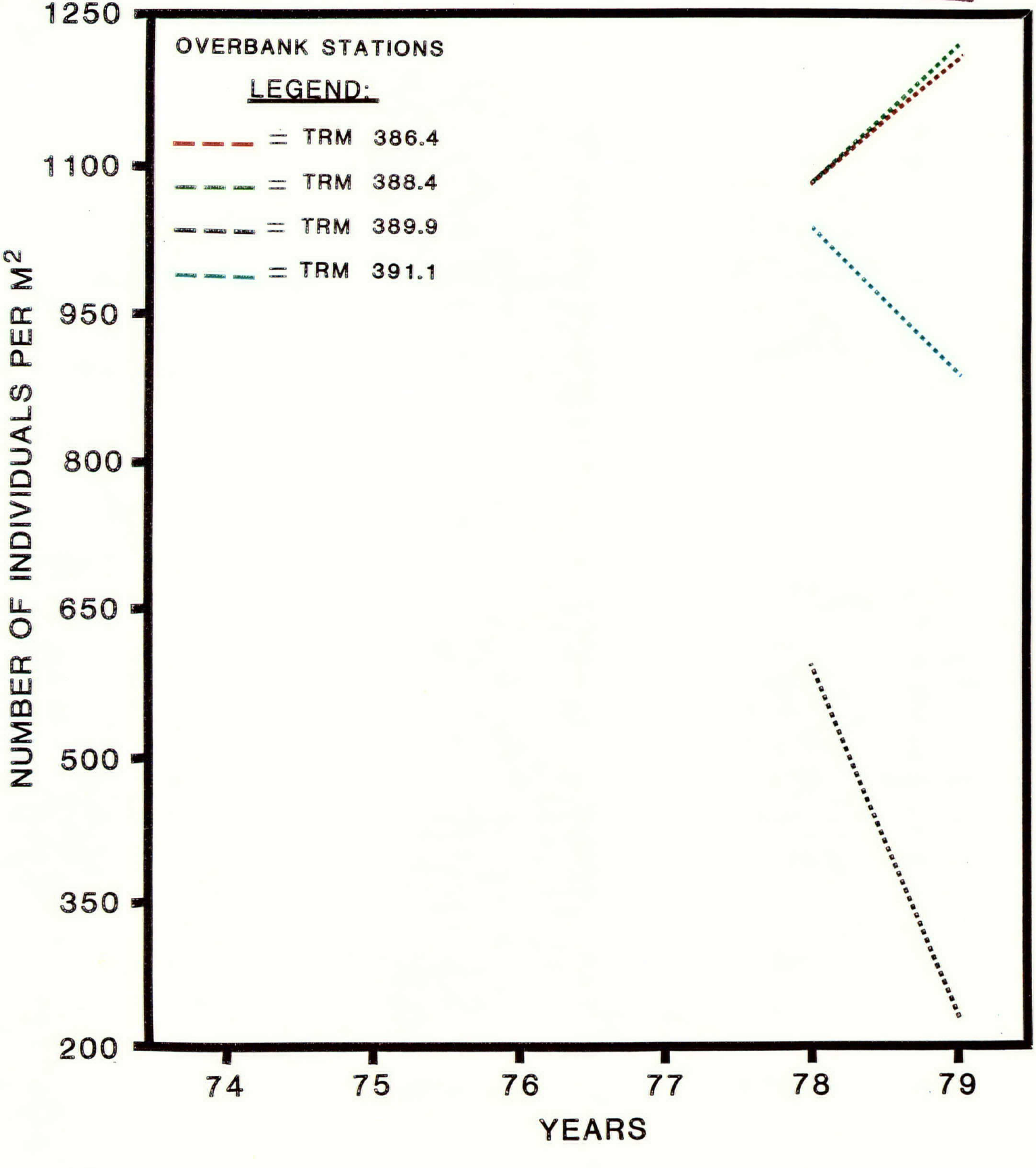


FIGURE 9.10 - OVERBANK STATIONS

MAXIMUM YEARLY DENSITY OF BENTHIC MACROINVERTEBRATES COLLECTED IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT 1974-1979

10.0 AQUATIC MACROPHYTES

Introduction

Aquatic macrophytes growing in, on, or near the water make up an integral part of the aquatic environment. They serve as a valuable food source and nesting site for waterfowl and provide favorable habitat for many species of aquatic organisms including macroinvertebrates and fish. In addition, they are important in nutrient and mineral cycles and even act as filters helping to clean polluted waters. At times, however, excessive growths of certain species (usually exotics, introduced by man) cause severe water-use problems by impeding navigation, clogging water intakes, interfering with water contact sports, and providing breeding habitat for mosquitoes and other troublesome insects.

Materials and Methods

Aerial color photographs were made of aquatic habitats in the vicinity of the plant site (at TRM 388.0 to 397.0) annually from 1975 through 1979. Dates of aerial overflights and approximate scale of photographs are presented in table 3.3. Ground truth observations were used to aid in interpretating the color imagery. These photographs form the basis for monitoring the extent of colonization of Eruasian watermilfoil (*Myriophyllum spicatum* L.) and other aquatic macrophytes that exist in the vicinity of the BNP.

In order to monitor quantitative changes in the aquatic macrophyte vegetation above and below the BNP site, six sampling stations were selected (figure 3.2) which reflect the two representative littoral habitats, i.e., the shallow overbank and the originally inundated river bank habitats. The original river bank stations are located at TRM 396.8 (station 1), TRM 389.4 (station 6), and TRM 389.5 (station 7). The shallow overbank stations are located at TRM 396.0 (Raccoon Creek Mile 0.1--station 2), TRM 389.4 (Sublett Ferry--station 5), and TRM 389.5 (Jones Creek--stations 7 and 8) (table 3.4 and figure 10.1). Stations 1, 2, 5, and 6 were sampled from January 1974 through 1979. Stations 7 and 8 were added in March 1978 as a result of modifications in the plant design. Two other stations (3 and 4) were sampled as a part of construction monitoring but have not been included in this report.

All stations were sampled at approximately bimonthly intervals corresponding to the phenologic dynamics of the dominant aquatic macrophyte species. Samples of aquatic macrophytes were collected from the entire water column in five 0.1 m^2 quadrats at each 1.5-foot contour interval along a belt transect oriented perpendicular to the bottom contour. In a few instances, samples collected in the early portion of 1974 were at 1.0-foot contour intervals. Samples from deeper depths were collected by divers using SCUBA (Self Contained Underwater Breathing Apparatus). The samples were separated by species in the laboratory and thoroughly washed to remove foreign debris. Samples were then oven-dried and ashed to determine ash-free dry weight. The mean standing crop, expressed in g/m^2 ash-free dry weight was calculated for each contour interval at each station for each bimonthly sample period. These means were then summed at each station. The summed means, representing an estimate of the standing crop at each station, were plotted for each survey conducted from January 1974 through December 1979 (figures 10.5-10.7).

Results

The extent of colonization of aquatic macrophytes in the site vicinity is shown in figure 10.2 and is based on 1978 and 1979 aerial photographs. Eurasian watermilfoil (*Myriophyllum spicatum* L.), a submersed species was the dominant aquatic macrophyte in the project area. Several other submersed species such as *Egeria densa* Planchon, *Ceratophyllum demersum* L., *Najas minor* All., *N. quadalupensis* (Sprengel) Magnus, *Potamogeton crispus* L., *Vallisneria americana* Michx., and *Zanichellia palustris* L. also occurred in the shallow littoral zone along the mainstream channel and the shallow overbank areas. A floating-leaved species, *Potamogeton nodosus* Poir. was quite common in protected areas along the channel and embayments of the overbank. Several emergent taxa such as *Zizaniopsis miliacea* (Michx.) Doell and Ascherson, *Alternanthera philoxeroides* (Martius) Grisebach, *Justicia americana* (L.) Vahl, *Cephalanthus occidentalis* L., Nelumbo lutea (Willd.) Persoon, Eleocharis quadrangulata (Michx.) R.& S., and several species of sedges inhabited shoreline margins and shallow littoral habitats.

Submersed aquatic macrophyte communities dominated by Eurasian watermilfoil are shown in figure 10.2 in addition to mixed emergent communities, and monotypic stands of Alternanthera philoxeroides and Nelumbo lutea. A comparison of aerial photographs from 1975 through 1979 shows the spatial distribution of most aquatic macrophyte communities to have undergone only minor fluctuations and to be largely within the range expected under normal climatic fluctuations. A reduction in the areal coverage of submersed macrophyte communities was noted in 1977 but by 1978 and 1979 coverage had returned to former observed levels. Protected overbank areas to the north and south of the confluence of Mud Creek became infested with watermilfoil over the period 1975 to 1979. A major reduction in the areal coverage of watermilfoil colonies along the overbank above the intake occurred in 1976. Approximately 39 acres of watermilfoil were treated with DMA 2,4-D in May 1976 to free the area of vegetation to facilitate preoperational monitoring of larval fish. By 1978, Eurasian watermilfoil had recolonized the area to the extent prior to herbicidal treatment. The treatment was conducted in accordance with the procedures identified in the TVA Final Environmental Statement "Control of Eurasian watermilfoil (Myriophyllum spicatum L.) in TVA Reservoirs, September 1972."

The quantitative sampling of selected belt transects to provide standing crop estimates, showed Eurasian watermilfoil to be the dominant species in the study area (figures 10.3 through 10.7). Maximum standing crop of watermilfoil occurred in summer to early fall in most instances. Two other species, coontail (Ceratophyllum demersum) and Brazilian elodea (Egeria densa), frequently occurred at some stations but standing crops were generally much less than observed for watermilfoil. Species occurring infrequently and in trace amounts have been omitted from the figures showing standing crop for Eurasian watermilfoil, Brazilian elodea, and coontail. Standing crop, collection date, and location (station) of these infrequently collected species are presented in table 10.2.

No aquatic macrophytes were found at station 1 until Eurasian watermilfoil was collected in July 1977. Maximum standing crop data for 1977 and 1978 were similar with a three-fold increase observed in 1979 (figure 10.3). Brazilian elodea and P. nodosus were collected in small amounts during 1979 surveys (figure 10.3, table 10.2).

Several species of aquatic macrophytes, C. demersum, Potamogeton sp., N. quadalupensis, and one unidentified species occurred sporadically at station 2 (figure 10.4, table 10.2) and comprised a small percentage of the standing crop at this station. The dominant macrophyte, Eurasian watermilfoil, recorded the maximum standing crop during 1974 and declined until 1977, after which estimates of the maximum standing crop were comparable to one another (figure 10.4). Small amounts of E. densa were found in 1974 and 1975 but declined in 1976 and occurred sporadically thereafter (figure 10.4).

The maximum standing crops for Eurasian watermilfoil at station 5 occurred in 1974 and 1975 and declined thereafter (figure 10.5). Small amounts of E. densa were found at this station from 1974 through 1977 with maximum standing crop occurring in 1977 (figure 10.5).

The maximum standing crop of watermilfoil at station 6 occurred in 1974 and declined until 1976 when the standing crop failed to exceed 15 g/m^2 (figure 10.6). Maximum standing crop estimates for 1977 through 1979 are similar but are less than half the maximum standing crop estimated in 1974. Small numbers of Egeria densa were present in 1974-1976 but occurred sporadically in 1977-1979. Other species at this station with sporadic occurrences include C. demersum and V. americana (table 10.2).

Due to the short sampling period (i.e., two years) for stations 7 and 8, no trends are apparent. Eurasian watermilfoil is the dominant macrophyte at both stations with maximum standing crops in 1979 exceeding those of 1978 (figure 10.7). Small amounts of E. densa were found at station 7 in addition to a single collection of V. americana (table 10.2). Small amounts of C. demersum were found at station 8 during 1978 and 1979 with E. densa, P. crispus, and Z. palustris also occurring sporadically (figure 10.7, table 10.2).

A comparison of stations 2, 5, and 6 during the sampling period indicates a decrease in maximum standing crop from 1974 to 1979. At these three stations the maximum standing crop occurred during 1974 and 1975 and declined thereafter. An exception to this trend is station 1 which was colonized by watermilfoil during the fourth year of the sampling period. The increase in maximum standing crop since colonization probably reflects the spread of watermilfoil to unoccupied habitat at this station. The reason for the sharp decrease in maximum standing crop at station 6 in 1977 is unknown. Unexplained variation in the growth of *Myriophyllum spicatum* colonies in this area had been previously observed. Stations 7 and 8 showed increases in maximum standing crop from 1978 to 1979.

Table 10.1

SAMPLE LOCATIONS FOR AQUATIC MACROPHYTES IN THE VICINITY OF THE BELLEFONTE NUCLEAR PLANT, GUNTERSVILLE RESERVOIR

Station[a]	Location	Habitat description	Approximate sampling depth (ft)
1	TRM 396.8 (Raccoon Creek)	Main stream	0 to 7
2	TRM 396.0 (Raccoon Creek)	Shallow overbank	1 to 5
5	TRM 389.4 (Sublett Ferry)	Main stream	0 to 7
6	TRM 389.4 (Sublett Ferry)	Shallow overbank	0 to 5
7	TRM 389.5 (Jones Creek)	Main stream	0 to 7
8	TRM 389.5 (Jones Creek)	Shallow overbank	0 to 5

a. Two other stations (3 and 4) were sampled as a part of construction monitoring but have not been included in the preoperational report.

Table 10.2

INFREQUENTLY COLLECTED MACROPHYTES FROM THE VICINITY OF THE BELLEFONTE NUCLEAR SITE (1974-1979)

Taxon	Station	Collection date	Sum mean standing crop (g/m^2)
Najás quadalupensis	2	March 18, 1974	0.08
	2	May 21, 1974	0.01
	2	July 10, 1974	0.01
	5	September 12, 1974	0.11
Potamogaton crispus	8	December 5, 1978	0.08
	8	February 14, 1979	0.01
	8	May 10, 1979	0.02
Potamogeton nodosus	1	August 2, 1979	0.62
	1	October 2, 1979	3.70
Potamogeton sp.	2	February 22, 1977	0.03
Vallisneria americana	7	May 10, 1979	0.06
	6	December 6, 1979	0.15
Zanichelliapalustris	8	February 14, 1979	0.01
Unidentified species	2	April 20, 1976	2.84

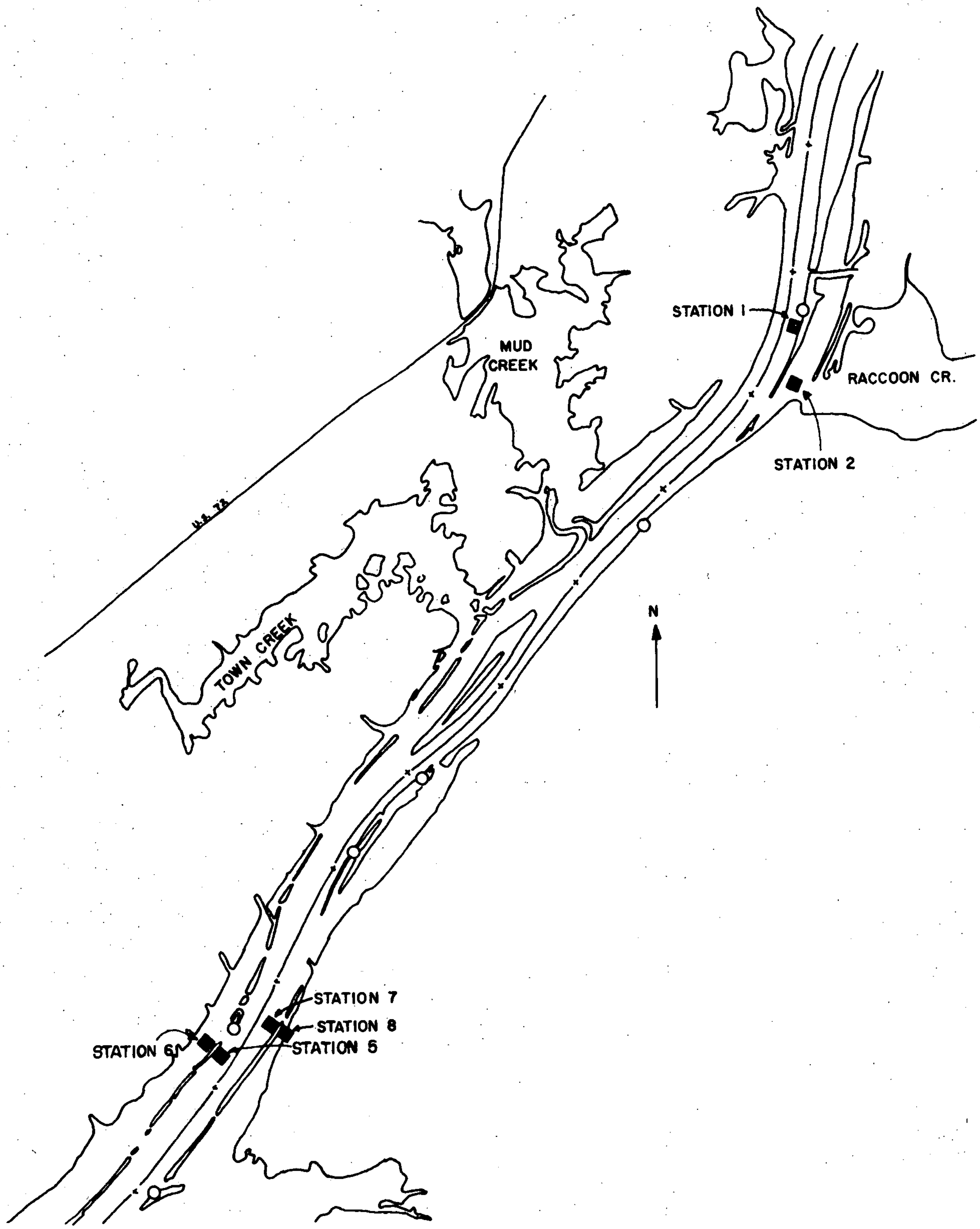


Figure 10.1 Sampling Stations for Aquatic Macrophytes in the Vicinity of the Bellefonte Nuclear Plant

POOR ORIGINAL

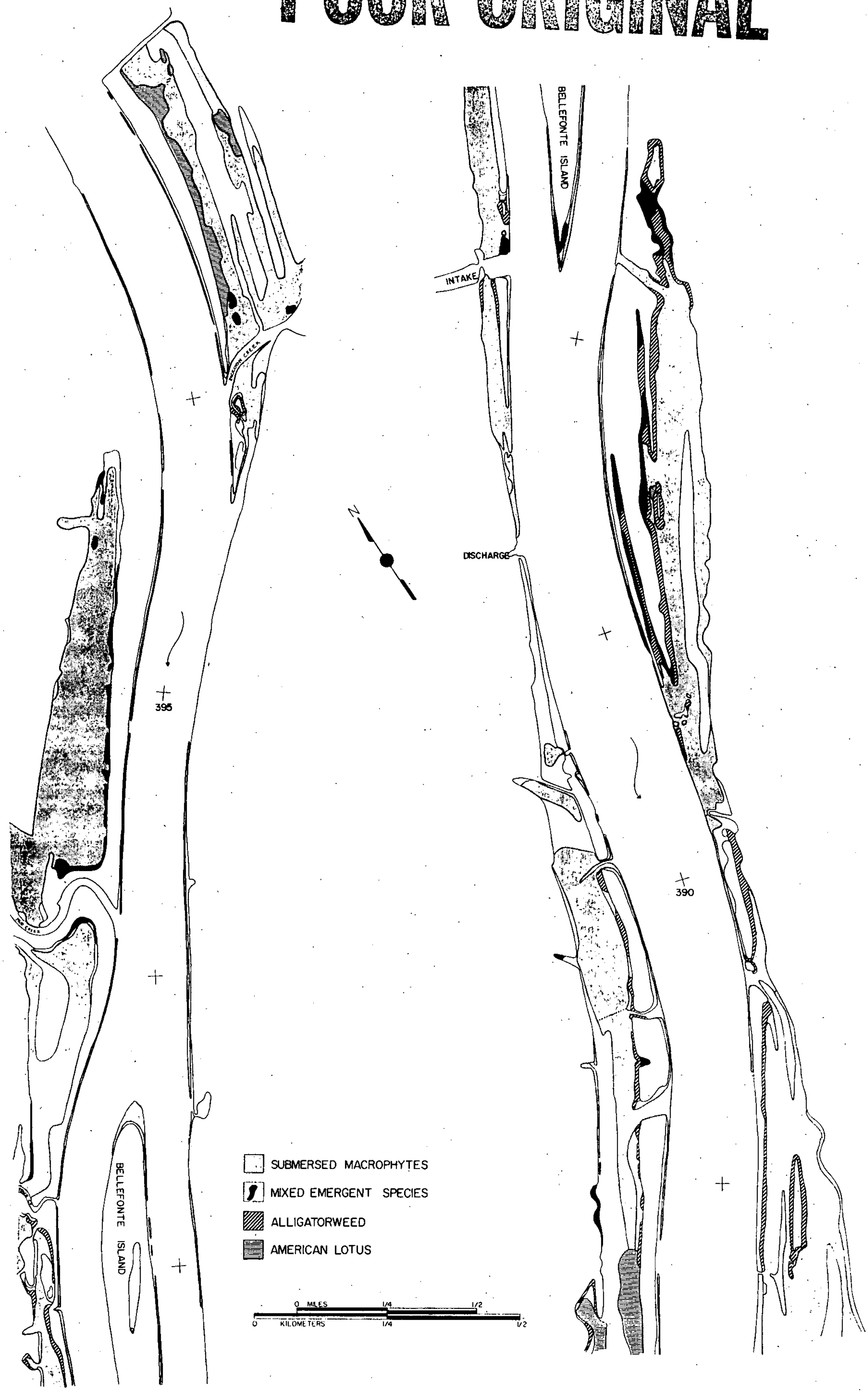


Figure 10.2 Aquatic Macrophytes in the Vicinity of the Bellefonte Nuclear Plant

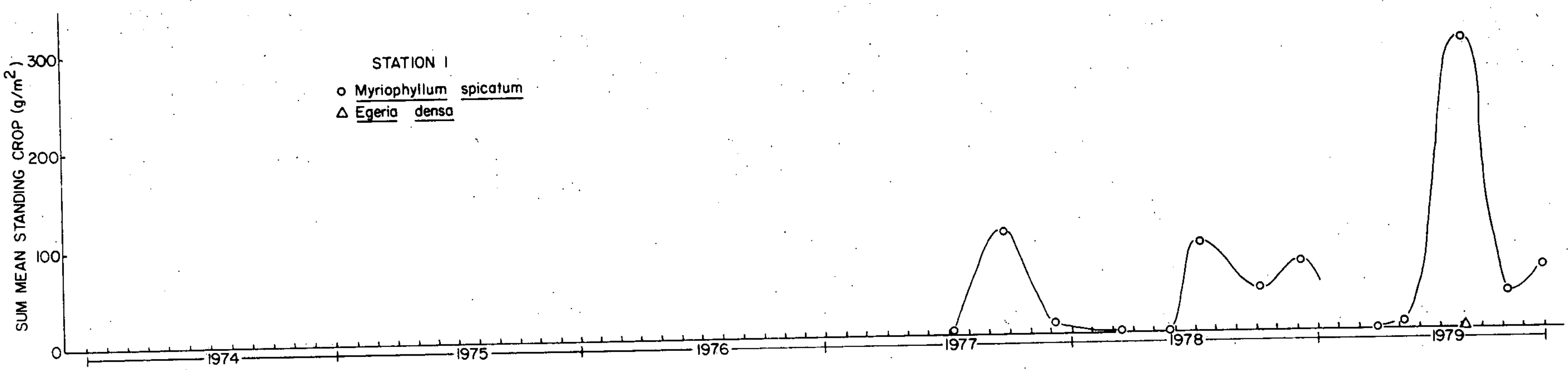


Figure 10.3 Sum Mean Standing Crop for _Myriophyllum spicatum_ and _Egeria densa_ at Sampling Station 1

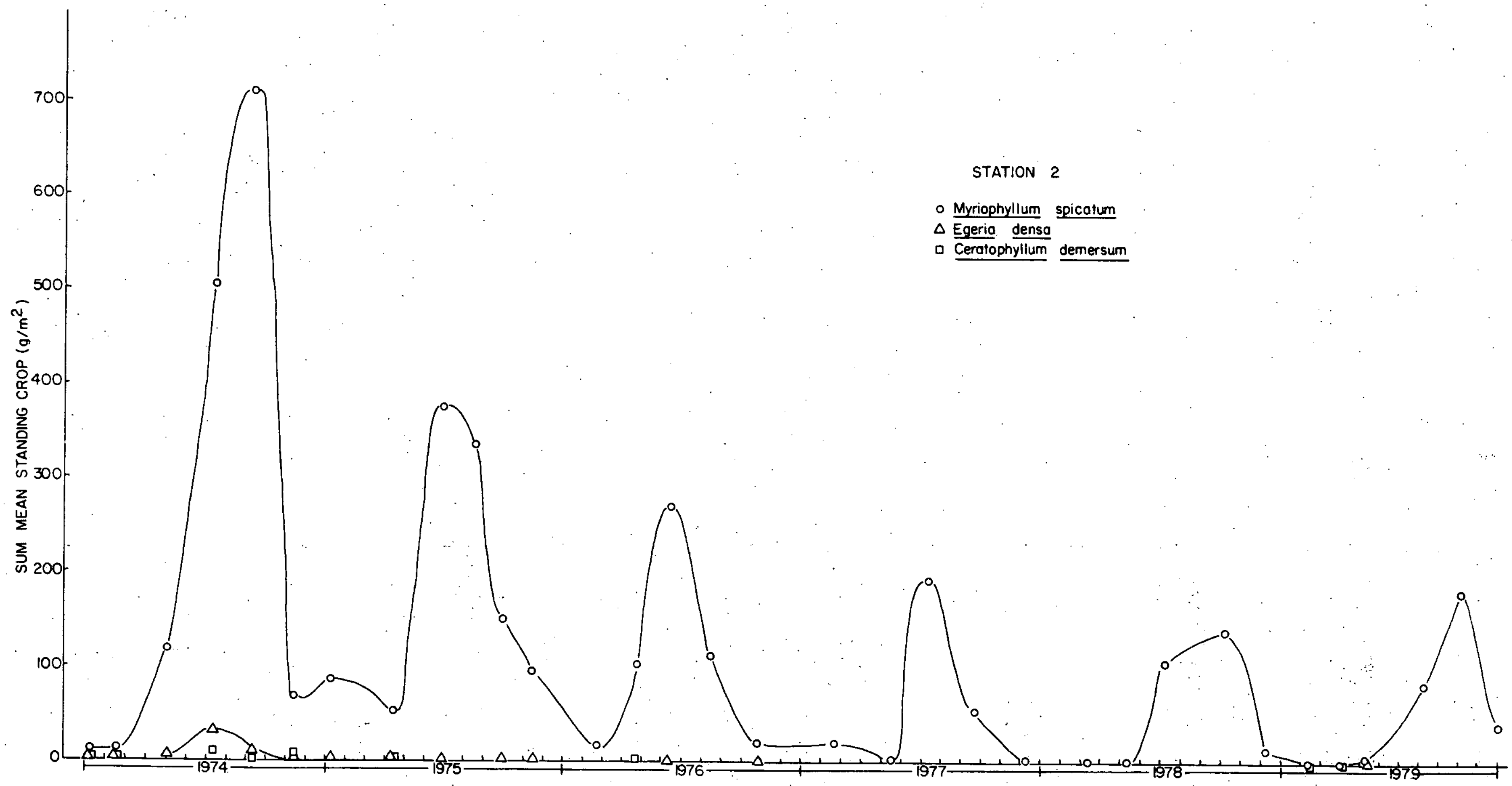


Figure 10.4 Sum Mean Standing Crop for *Myriophyllum spicatum*, *Egeria densa*, and *Ceratophyllum demersum* at Sampling Station 2

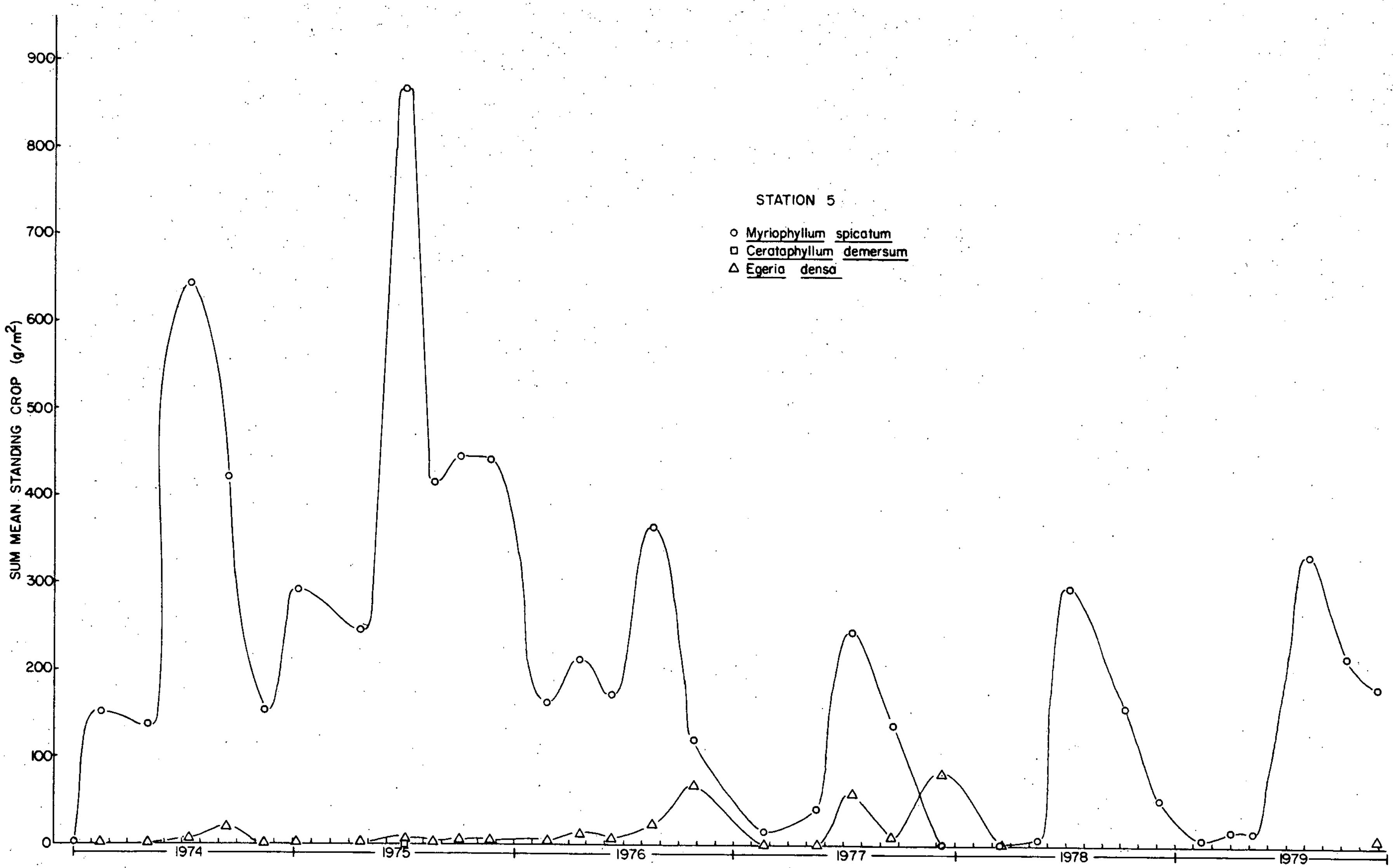


Figure 10.5 Sum Mean Standing Crop for Myriophyllum Spicatum, Egeria densa, and Ceratophyllum demersum at Sampling Station 5

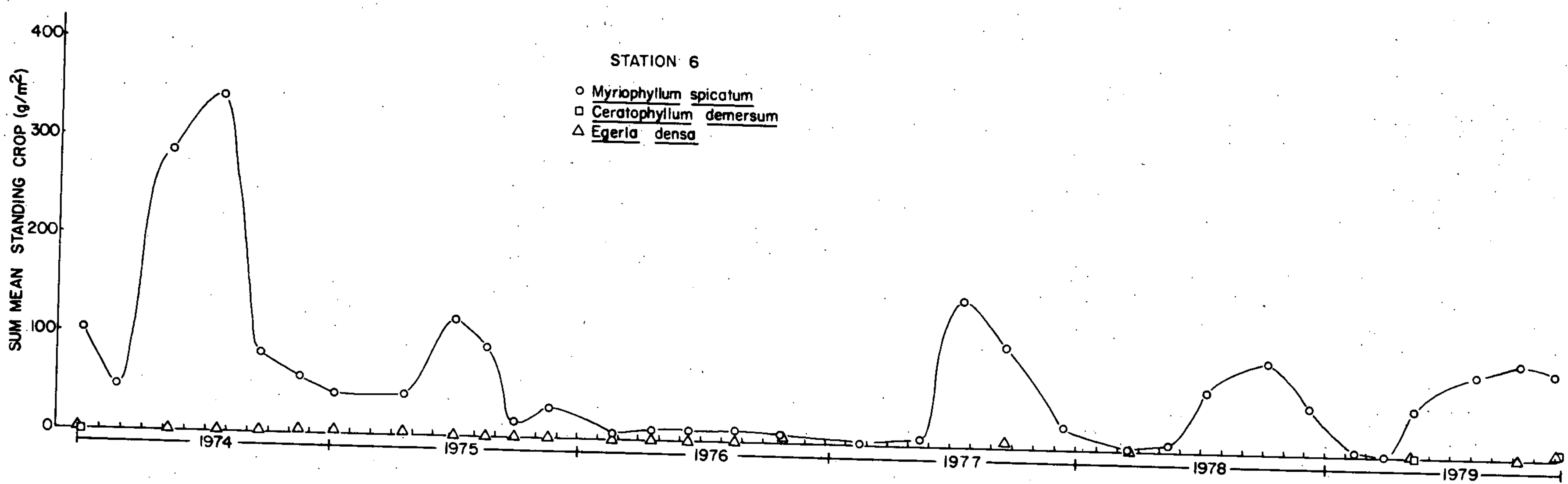


Figure 10.6 Sum Mean Standing Crop for Myriophyllum spicatum, Egeria densa, and Ceratophyllum demersum at Sampling Station 6

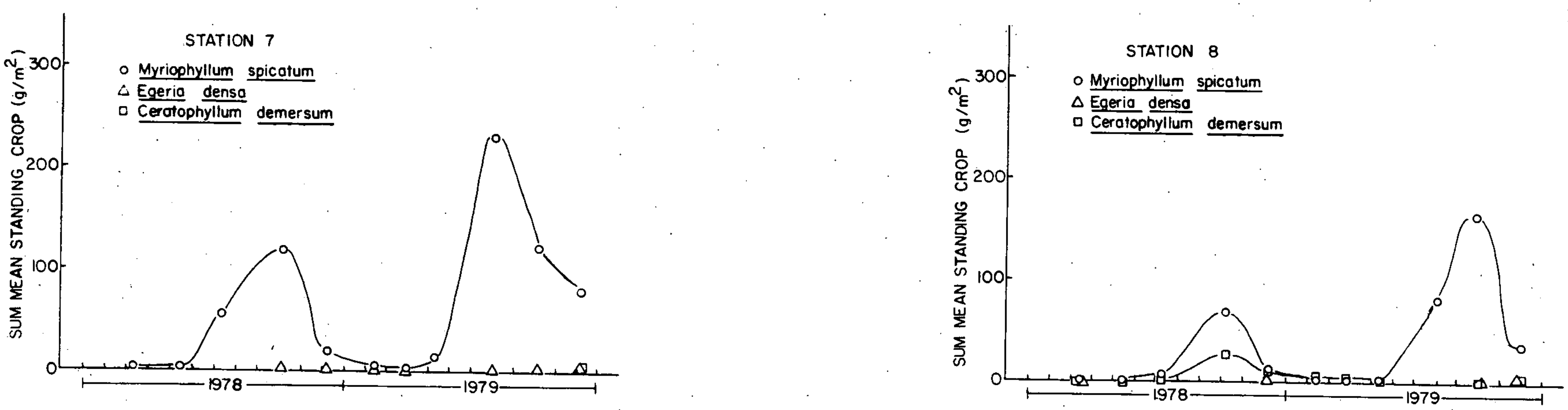


Figure 10.7 Sum Mean Standing Crop for *Myriophyllum spicatum*, *Egeria densa*, and *Ceratophyllum demersum* at Sampling Stations 7 and 8

11.0 SUMMARY

Introduction

Preoperational aquatic biological and water quality monitoring programs were implemented at the BNP Plant site on Guntersville Reservoir, Alabama, in February 1974, and terminated in October 1979. Plans for these monitoring programs were originally described in the Final EIS for the BNP. This report compiles and analyzes data collected during the monitoring period and provides a summary description of the aquatic environment in Guntersville Reservoir in the vicinity of the BNP. Summary discussions of results of the monitoring program for each of the parameters investigated are presented below.

Water Quality

Maximum water temperatures at the BNP site were found to naturally exceed the State of Alabama criterion of 30°C during the late summer. Measured concentrations of DO were less than the State criterion of 5.0 mg/l. Both temperature and DO excursions from State standards are influenced by the release of high temperature, low DO water from Nickajack Dam. The pH values exceeding 8.5 were probably due to high photosynthetic activity.

Total alkalinity concentrations averaged 51 mg/l, which indicates a limited buffering capacity. Chemical quality of the water was very good as mean values of all parameters listed in the National Primary Drinking Water Standards and in EPA's Quality Criteria for Water were met.

Sediments

Channel stations were characterized mostly by gravel and sand substrates with small amounts of silt, clay, or organic materials. The most noticeable change occurred at TRM 388.0, when silt increased from 2.6 percent in 1977 to 17.5 percent in 1978. Other channel stations showed only slight increases in clay and silt in 1978. An analysis of correlation (p = o) showed a highly significant relationship between silt and time (r = 0.77433) at TRM 388.0. A highly significant relationship between clay and time (r = 0.73160) was also documented at this station. No significant changes occurred at the other stations.

Phytoplankton

During 1974 to 1979 phytoplankton was sampled monthly from February to October to establish baseline descriptions of communities in the vicinity of the BNP. Enumeration, chlorophyll a, and primary productivity data were gathered.

No unusual or unexpected patterns of phytoplankton distribution were indicated by the spatial and temporal distribution of genera. The genera collected were typical for mainstream Tennessee River reservoirs. Communities at the channel stations were more similar to each other than to the station at TCM 0.2. Differences between river stations and the creek station were probably due to habitat differences.

Phytoplankton communities were diverse and composed primarily of Chrysophyta, Chlorophyta, and Cyanophyta. Chrysophyta dominated the phytoplankton communities in numbers from February through May and then Cyanophyta dominated from June through October. Cyanophyta dominance occurred both upstream and downstream from the plant site and is expected to continue into the operational phase of the plant.

There was only one sampling period out of 53 when the diversity ($\bar{d}$) index was below 1.0. This provides one indication that there were not adverse environmental conditions during the monitoring period.

Seasonal community numbers of phytoplankton appeared to be typical for similar reaches of other Tennessee River mainstream reservoirs. Maximum standing crop usually occurred in the summers and minimum standing crop in early spring and fall.

Chlorophyll a and primary productivity data were highly variable and difficult to relate to water quality and light data. A correlation was not apparent between these and other phytoplankton community parameters.

Aufwuchs

A total of 97 genera were collected on artificial substrates during the monitoring period. A breakdown of the genera by major division showed Chlorophyta with 43, Chrysophyta with 31, Cyanophyta with 15, Pyrrhophyta with 4, Euglenophyta with 3, and Cryptophyta with 1. The most commonly occurring genera were *Achnanthes*, *Cocconeis*, *Cymbella*, *Gomphonema*, *Melosira*, *Navicula*, *Synedra*, *Cosmarium*, *Stigeoclonium*, and *Oscillatoria*.

The standing crop values ranged from 7693.2 x $10^6/m^2$ at TRM 396.8 in June 1976, to 103.1 x $10^6/m^2$ at TRM 391.2 in July 1978. Standing crop data did not show any specific trends.

AI values at all stations exceeded 100 in 1975 and as did most values in 1976. Values that exceeded 100 were recorded only 7 times in 1977 and 12 times in 1978.

Zooplankton

Preoperational monitoring for the BNP has provided data which demonstrate variations in the zooplankton community associated with seasonal factors or habitat differences. Standing crops on overbanks were much higher than at the channel stations, probably due to more suitable habitat resulting from lower difference in river flow rates on the overbanks. The overall standing crop was highest in 1977 and lowest in 1975.

The variation in diversity ($\bar{d}$) and standing crop of zooplankton appeared to be most influenced by seasonal conditions. The $\bar{d}$ values were generally higher in the summer months and lower in the fall and winter. The pattern of mean standing crops was more inconsistent than $\bar{d}$ values. In 1976 and 1977, standing crops at mainstream stations were higher in February than they were during any other month during the year. In 1974, standing crop peaked in May with a range of $63.0 \times 10^3/m^3$ to $122.0 \times 10^3/m^3$, while the following year 1975, the standing crop varied only from 0.6 to $8.4/m^3 \times 10^3$ from February to October.

Benthic Macroinvertebrates

Artificial substrate samplers collected 39 taxa of benthic macroinvertebrates during the monitoring period. Taxa that occurred most often were *Limnodrilus*, *Hexagenia*, *Caenis*, *Chironomus*, *Corbicula*, *Stenonema*, and *Cyrnellus*.

A total of 97 taxa of benthic macroinvertebrates was collected in Ponar grab samples from the vicinity of the BNP during preoperational monitoring. Taxa that occurred in numbers of $100/m^2$ two or more times were *Ablabesmyia*, *Branchiura*, *Caenis*, *Chironomus*, *Coelotanypus*, *Corbicula*, *Cryptochironomus*, *Dicrotendipes*, *Glyptotendipes*, *Hexagenia*, Hirudinea, *Hyalella*, *Limnodrilus*, *Parachironomus*, *Polypedilum*, and *Procladius*.

Diversity ($\bar{d}$) values suggest that no major stresses affected the benthic macroinvertebrate community during the monitoring period. Diversity values of less than 1.0 occurred frequently, but were attributed to large numbers of *Corbicula* in the samples.

Aquatic Macrophytes

Eurasian watermilfoil (*Myriophyllum spicatum* L.) was the dominant aquatic macrophyte in the project area. Other submersed species that were quite common were Egeria densa, Ceratophyllum demersum, Najas minor, N. quadalupensis, Potatogeton crispus, Vallisneria americana, and Zanichellia palustris. A floating-leaved species, Potamogeton nodosus was common in protected areas along the channel and embayments of the overbank. Emergent taxa such as Zizaniopsis miliacea, Alternanthera philoxeroides, Justicia americana, Cephalanthus occidentalis, Nelumbo lutea, and Eleocharis quadrangulata inhabit shoreline margins and shallow littoral habitats.

Colonies of aquatic macrophytes in the vicinity of the BNP were relatively stable during the preoperational monitoring period. Changes noted in the area were those caused by herbicidal treatments or the establishment of macrophytes in previously uncolonized overbank areas.